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MILITARY OPERATIONS RESEARCH SOCIETY

Evolving the Practice of Military Operations Analysis in DoD Workshop

29 February - 2 March 2000
Naval Postgraduate School
Monterey, California

Chair
Denis Clements
Co-Chair
Sue Iwanski

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Table of Contents

PAGE

TABLE OF CONTENTS ..... **V**
FIGURES ..... **VII**
TABLES ..... **VII**
EXECUTIVE SUMMARY **E-1**
BACKGROUND E-1
DISCUSSION E-1
GOALS AND OBJECTIVES E-2
Goals *E-2*
Objectives *E-2*
APPROACH E-2
WORKING GROUP SESSIONS E-3
WORKSHOP SYNOPSIS E-3
THE ACTION PLAN E-3
SUMMARY E-6
WORKSHOP REPORT **1**
BACKGROUND 1
DISCUSSION 1
GOALS AND OBJECTIVES 2
Goals *3*
Objectives *3*
APPROACH 3
Plenary Session Presentations *3*
WORKING GROUP SESSIONS 6
Working Group 1, Management of Analytic Knowledge *6*
WG 1 Session Summary 7
Moving From "Siloed" to Enterprise Knowledge 7
Lessons from the Private Sector 7
A Strategy for Improving Operations Analysis in DoD 8
Description and Discussion of WG 1 Findings and Recommendations 8
Working Group 2, Enabling Collaboration *10*
WG 2 Session Summary 10
Where Does Collaboration Exist in Analysis Today? 10
Formal and Informal Techniques that Enable Collaboration 11
Data Collection and Production 12
Description and Discussion of WG 2 Findings and Recommendations 12
Working Group 3, New Analysis Challenges *13*
WG 3 Session Summary 13
Analysis Problems that are not Well-Served by Current Analysis Techniques or Approaches 13
Problems with the Current Emphasis 14
Description and Discussion of WG 3 Findings and Recommendations 15
Working Group 4, New Analysis Tools and Methods *15*
WG 4 Session Summary 15
Assumptions and Scope 16
Analytical Requirements 16
A Knowledge Management Framework for Analysis 17
An Architecture of Systems, Software, and Models to Support Analysis 18
Description and Discussion of WG 4 Findings and Recommendations 19
The Synthesis Group Report *19*
The Tool and Challenge Matrix 20
Analysis to Support Decision Making 22
The Action Plan 25
Summary 27

APPENDIX A: ACRONYMS **A-1**
APPENDIX B: WORKING GROUP AND SYNTHESIS GROUP REPORTS **B-1**
WORKING GROUP 1: MANAGEMENT OF ANALYTIC KNOWLEDGE B-1
WORKING GROUP 2: ENABLING COLLABORATION B-1
WORKING GROUP 3: NEW ANALYSIS CHALLENGES B-1
WORKING GROUP 4: NEW ANALYSIS TOOLS AND METHODS B-1
SYNTHESIS GROUP B-1
APPENDIX C: TERMS OF REFERENCE **C-1**
APPENDIX D: PARTICIPANTS **D-1**

Figures

PAGE

FIGURE E-1. POTENTIAL FUTURE "FRAMEWORK" E-4
FIGURE 1. EPISTEMOLOGICAL ARCHITECTURE 5
FIGURE 2. INTERRELATIONSHIPS RELATED TO COLLABORATION, CREATION AND REUSE 9
FIGURE 3. ANALYSIS PROCESS IN THE CONTEXT OF KNOWLEDGE MANAGEMENT 17
FIGURE 4. ANALYSIS PROCESS ALTERNATIVE VIEW 17
FIGURE 5. THE FUTURE "FRAMEWORK" FOR ANALYSIS 18
FIGURE 6. TOOL / CHALLENGE MATRIX 20
FIGURE 7. ANALYSIS TO SUPPORT DECISION MAKING 22
FIGURE 8. EMERGING PRESSURES 24
FIGURE 9. CHALLENGES 24
FIGURE 10. POTENTIAL FUTURE "FRAMEWORK" 25

Tables

PAGE

TABLE E-1. WORKSHOP ORGANIZATION E-3
TABLE E-2. SUMMARY RECOMMENDATIONS E-5
TABLE 1. WORKSHOP ORGANIZATION 3
TABLE 2. MAKING RESULTS RELEVANT 5
TABLE 3. CONTRASTING VIEWS OF KNOWLEDGE ACCESS 7
TABLE 4. SUMMARY RECOMMENDATIONS 26

Executive Summary

Background

Leaders in the DoD analysis community are calling for an examination of how we perform analyses. They are asking us whether our analysis practices warrant examination with a view towards improving their effectiveness.

The management of knowledge, how to prepare to perform the next analysis, how to perform the next analysis, how to gather information needed to support analysis, and how to find and apply analytic insights from past studies, are becoming principal factors in being able to meet decision makers' expectations in regard to both the quality of an analysis and the speed with which an analysis is accomplished.

"Making Analysis Relevant" was the topic of a *PHALANX* article by Vince Roske in early 1998.[1] Mr Roske reiterated a recipe provided by John D. (Dave) Robinson, MG USA, Ret, when he was the Director of J-8. The recipe is provided below:

- *What's the question?*
- *What's the "real" question?*
- *What do the final slides look like?*
- *What do I already know?*
- *How do I get the remaining information that I need?*

Dave Robinson's recipe is reminiscent of the practical battle drills used by the military to train soldiers to do basic tasks. It is simple, it is memorable, and it will get the job done. Mr Roske goes on to look deeper at each of the recipe steps and discusses the issues associated with performing analysis today. He explains that we must focus on the purpose of the analysis and not become wed to models that don't fit the analysis. Furthermore, he explains what the analyst must do to keep the analysis relevant to the decision maker.

Discussion

The keys (and related impediments) to effective analysis in DoD are:

The analysts,

- Turnover and reduction in numbers of analyst positions in DoD organizations is creating a critical situation.

The knowledge that analysts access,

- DoD analysts are spread around the world and find it very difficult to collaborate.

The process by which analysts perform their work,

- DoD does not have a best practices guide to aid analysts in their work.

The tools that analysts employ to perform their work,

- The analytical methods and tools employed by DoD analysts are increasingly complex as are the problems to which the methods and tools are being applied.

The effectiveness with which analysts communicate analytical results to decision makers,

- The quantity, variety and complexity of military operations is increasing — the time to perform analysis and communicate results to decision makers is decreasing.

The proper management of knowledge can improve analytical efficiency by providing a framework, tools and techniques to reuse intellectual assets. By marshalling resources to respond to opportunities and threats, our responsiveness could be vastly improved. And by bringing people together across time and geography to share ideas and insight, intellectual innovation can flourish and bear richer insight for decision makers.

[1] Mr Vincent P. Roske, Jr., "Making Analysis Relevant," *PHALANX* Volume 31, Number 1, March 1998

This special meeting, comprising analysts and subject matter experts in approaches to analysis, concentrated on the improvement of the analysis practice throughout DoD. To achieve this end, participants enumerated potential issues related to a broad move towards more collaborative analysis and enterprise knowledge management and define the appropriate policies, organizational structure, processes, technologies and training needed to institutionalize an improved practice of analysis in DoD. These issues were addressed by Working Groups (WGs), addressing the spectrum of dimensions of organizational change, as well as supporting infrastructures and supporting tools and techniques.

Goals and Objectives

The body of analytical methods, techniques and tools and how we apply them was the focus of this workshop. We examined how we carry out our professional work and the need to evolve. Questions addressed included:

- What should be the customary manner for performing defense-related analyses?
- How do we manage the knowledge we derive from our analyses?
- How do we support both fast turn-around and more deliberate analyses?
- What problems are not well served by the current state of the practice?
- What innovative developments in analysis tools and methods, including Knowledge Management, hold potential value for DoD analysis?

Goals

This workshop afforded the military operations research community an opportunity to achieve the following goals:

- A shared understanding of the need to evolve the practice of military operations analysis in DoD.
- A vision for improving analytic practice and the management of supporting analytic knowledge in DoD.
- A plan to realize the vision to improve analytic practice and the management of supporting analytic knowledge in DoD.
- A definition of how Military Operations Research Society (MORS) may work with the Sponsors over time to implement improvements to analytic practice and to the management of analytic knowledge in DoD.

Objectives

The objectives were to:

- Define a desired analytic practice approach in DoD in terms of policy, organization, process, technology and training.
- Define current analytic practice in DoD in terms of policy, organization, process, technology and training.
- Identify weaknesses in the current practice relative to current and future requirements.
- Produce an actionable plan to move DoD to the desired state.
- Define mechanisms to be established within MORS to work with the DoD Sponsors to execute the plan.

Approach

In order to achieve these goals and objectives, the subject of analytic practice was examined in a number of different contexts. Working groups examined analytic practice within each contextual framework. WGs were asked to address some baseline issues (as a starting point) and provide specific results. The workshop sessions are listed in Table E-1.

Sessions	Topics	Leadership
Keynote Session	Dr Ruth David: Knowledge Management Jim Johnson: Perspectives on Requirements Analysis Bruce Powers: Perspectives on Capabilities Analysis	Workshop Lead Proponent: Vince Roske Workshop Chair: Denis Clements Workshop Co-Chair: Sue Iwanski
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Synthesis Group	Consolidating Recommendations and Developing an Action Plan	Group Chair: Dr Stuart Starr, FS Group Co-Chairs: Dr Jerry Kotchka, Dr Tom Allen

Table E-1. Workshop Organization

Working Group Sessions

The workshop attendees were organized into four subject area WGs of about 20 to 30 members each plus a Synthesis Group to address the overall goals and objectives.

WG 1, Management of Analytic Knowledge, examined the manner in which analytic knowledge is discovered, expanded, organized and shared.

WG 2, Enabling Collaboration, examined the process, tools and techniques that support distributed analytic teams in performing analytic tasks.

WG 3, New Analysis Challenges, examined military operations analysis questions of interest for which the established military operations analysis community apparently does not have answers.

WG 4, New Analysis Tools and Methods, examined emerging developments in analytical approaches to complex systems to assess potential applications to challenging military operations analysis problems.

The Synthesis Group sought to discover the common themes that tie together the efforts of the four subject area WGs and provide feedback to the groups on a continuing basis.

Workshop Synopsis

Figure E-1 shows an illustration of an ideal end-state for the current efforts to improve analytical practices. There are three families of models and simulations: M&S embedded in real-time command and control systems; training and exercise support simulations; and models and simulations used to support analysis (to include Test and Evaluation (T&E) analysis and analysis of non-warfighting issues such as infrastructure and business process improvement). Within each domain are a set of models and simulations tailored to the purpose at hand. No single model will apply universally across all domains, but in this ideal end state we have data, software objects and process representations shared across the domains where it is logically consistent with the model and purpose.

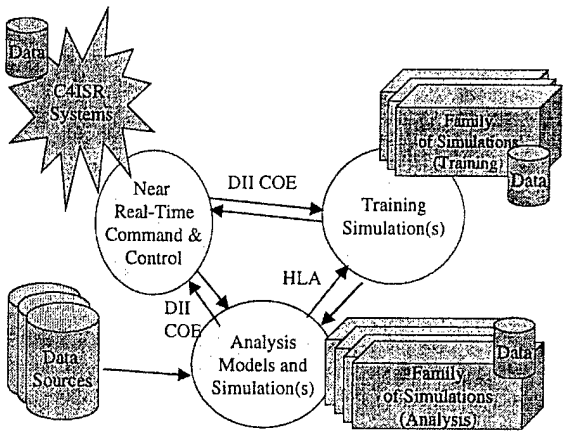

Figure E-1. Potential Future "Framework"

Infrastructure programs currently under development are assumed to be in place in this end state, to include the High-Level Architecture (HLA) for simulations and the DII COE linking all areas together. HLA federations, which may include simulations widely, distributed over space, will exist where appropriate, but these federations should be standardized and validated for consistency across federates before use. The creation of "on the fly" federations that grab objects and federates scattered across the DII to create unique environments is probably still not possible in this end state because there is no guarantee that the representations will be internally consistent (consistency is not assured even if data is passed through HLA), and it is unlikely that a single analyst or team located at a single site will be familiar with all of the objects or federates potentially available. Instead, these simulations may be combined through the use of collaborative analysis rather than software linkages.

All of the tools are presumed to be in a bed of warm data. That is, there is a data infrastructure that makes data readily available (with exhaustive metadata explaining the derivation and accredited use of the data) for all of these systems. For example, an analysis of real-world capability should be able to draw on the same data set showing current status and deployments of units that a real-time command and control system might use. Similarly, an analysis of a future capability (for example, a 2010 force in a particular scenario) should be able to draw on a validated and commonly used set of data to represent the scenario, system performance, OPFOR performance, etc. Generation and storage of this data requires a significant resource commitment within DoD, but it is necessary to achieve the desired end state.

A key feature of this environment is that the output of the models, as well as the results of specific analyses and the lessons learned from training and exercises are also added to the common database. This provides a useful source of information that can be of particular help to quick turn-around analyses, which may synthesize the outputs of previous models, exercises and analyses.

The Action Plan

The Synthesis Group identified a number of actions that should become part of a long-range action plan that the community should consider and flesh out over the next few years as it evolves the practice of military analysis in DoD.

There are several steps that MORS can implement immediately that have little work impact but enormous potential to improve the ability of this community to connect with each other and better meet the over all needs of its membership. In addition to the items listed below, the working groups provided a number of general and specific steps that will help the community learn to harness knowledge management and collaboration, as well as to address emerging issues in the changing security environment. Generalized recommendations endorsed by the workshop include working the people, process and technology problems in order to ensure a better final product.

Actions for MORS include:

- Near Term:
  Update the MORS membership directory and database with more information on each member.

  Evolve the role of the Electronic Media Committee to address enterprise knowledge management.

Contribute to a Code of Best Practices for Analysis and Joint Experimentation.

- Mid Term:
  Undertake focused workshop activity on this topic.

- Far Term:
  Use the Education Colloquia to address ideas that Knowledge Management is an important element of professional development.

Actions for DoD include:

The working group recommendations provide a phased approach to knowledge management and collaboration implementation by focusing on people, process, and technology and product, as well as list challenges and promising tools and methodologies to meet those challenges.

Table E-2 summarizes the focus and potential impact of the specific actions recommended. First, cultural changes are a necessary prerequisite to effective transformation of the analysis community (e.g., the need to dispel the myth that "knowledge is power"). Second are several organizational issues that must be addressed. One of these is to ensure top management buys in to this transformation. Another includes reassessing how security issues can be addressed in an information-centric, open environment. In the third area, decision-makers must recognize that the analysts involved in all phases of the assessment process constitute a critical intellectual resource.

Summary Recommendations
Vision/Policy: Develop and promulgate an Enterprise Vision and strategic directions.
Culture: Take action to remove deeply rooted cultural barriers (e.g., remove the incentives to hoard knowledge)
Organization: Ensure that there is buy-in by Top Management. Investigate organizational constructs including business rules that best enable global collaboration of military analysts.
People: Provide incentives to analysts to collaborate and share knowledge.
Process: Institutionalize processes to enhance collaboration and the sharing of tacit and explicit knowledge among the analytical community.
Analytic Tools: • Develop and emphasize joint standards in algorithm and data development. • Expand the development and maintenance of data warehouses. • Focus basic research and tool development to meet emerging challenges

Table E-2. Summary Recommendations

They must be given incentives to stimulate them to contribute and draw from future knowledge warehouses. Tying all this together are the links between the vision and the high level guidance to the analysis process and the primary products of that process (i.e., effective, timely, rigorous analyses). To implement this linkage, a set of enhanced processes is needed (e.g., institutionalized processes to diffuse tacit and explicit knowledge) supported by a broad set of tools (e.g., knowledge warehouses, collaboration tools). These processes and tools are constrained by available resources (e.g., funds, manpower) such that a special funding mechanism may be required to satisfy time-urgent joint needs. In particular, basic research must be continued in those areas where understanding of phenomenology is not available (human decision processes, Information Operations/Information Warfare (IO/IW), etc) as well as the continuing development of analysis tools to address the emerging challenges.

The Synthesis Group feels that by addressing the needs of the community to implement our vision, the practice of analysis can evolve from its current position of a limited toolkit and methodologies to address a limited number of issues to a complete tool set connecting analysts and decision makers to address the full array of national security challenges.

Summary

This workshop has demonstrated that there is great potential to be realized from the harnessing of the knowledge in our heads and in the systems that support our analytical efforts. In addition, there is great power in undertaking a more collaborative approach to the analyses that we perform. The combination of enterprise knowledge management and collaboration can deliver better analysis products faster.

The way ahead to realize this vision will be difficult. Nothing less than a cultural change is required. The demands of the national security environment require that we find ways to alter the information security environment to permit knowledge sharing and collaboration on an enterprise scale. Getting analysts to collaborate and breaking down the barriers to that collaboration and knowledge sharing are fundamental changes that require bottom up as well as top down change.

The members of this workshop acknowledge the potential value of such change. It is now up to us to obtain the buy-in of the DoD leadership by convincing them that the benefits are worth the investment of time, money and energy to realize the vision articulated by this workshop.

Workshop Report

Evolving the Practice of Military Operations Analysis in DoD
Applying Knowledge Management

Background

Leaders in the DoD analysis community are calling for an examination of how we perform analyses. They are asking us whether our analysis practices warrant examination with a view towards improving their effectiveness.

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Discussion

The first three steps in General Robinson's recipe address critical steps in organizing and focusing an analysis or study. Answering *"What's the question?"* and *"What's the "real" question?"* enables the analyst to frame a study so that there is a chance that it may ultimately be relevant to the needs of the decision maker. Answering *"What do the final slides look like?"* up front serves the dual purpose of stressing the importance of communicating results to the decision maker and focusing the analysis efforts from the beginning.

But the substantive content of the analysis is contained in the last two recipe steps: *"What do I already know?"* and *"How do I get the remaining information I need?"* Evolving the practice of military operations analysis in DoD must therefore substantively address these last two questions.

One of the keys to successfully evolving the practice of analysis is the innovative management and application of knowledge, both tacit (the knowledge in the minds of the experts) and explicit (the knowledge that is recorded in various ways). There is an explosion of new thinking and new supporting technology to capture and apply knowledge more effectively. This area includes innovation in the discovery, expansion, capture, organization and sharing of knowledge. Innovations include: correlation landscapes, data mining tools, virtual information centers and influence diagrams.

[2] Mr Vincent P. Roske, Jr., "Making Analysis Relevant," *PHALANX* Volume 31, Number 1, March 1998

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The effectiveness with which analysts communicate analytical results to decision makers,

- The quantity, variety and complexity of military operations is increasing — the time to perform analysis and communicate results to decision makers is decreasing.

Information is a source for good decision making, however, a piece of information is more valuable when presented in context, that is, with other pieces of related information that makes the original information more meaningful and actionable. For instance, a study of the effectiveness of a proposed Intelligence, Surveillance and Reconnaissance (ISR) system may provide important information, but it is much more meaningful and actionable when analyzed in the context of national security policy and DoD objectives and when related to operational outcomes.

In DoD, we analysts don't know what we know, and consequently, we are bound to reinvent the wheel many times. We do not have automated enterprise repositories which hold accessible, important, explicit knowledge nor do we have the means to locate the right subject matter experts quickly and easily to access their tacit knowledge.

The proper management of knowledge can improve analytical efficiency by providing a framework, tools and techniques to reuse intellectual assets. By marshalling resources to respond to opportunities and threats, our responsiveness could be vastly improved. And by bringing people together across time and geography to share ideas and insight, intellectual innovation can flourish and bear richer insight for decision makers.

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Table 1. Workshop Organization

Plenary Session Presentations

The Keynote speaker was Dr Ruth David, CEO of ANSER a Federally Funded Research and Development Center (FFRDC), who discussed "Enterprise Knowledge Management." In the context of a hypothetical story with the entire national security apparatus as the enterprise and Homeland Defense as the strategic objective, she explained that in the 21st century our nation's security would depend on effective knowledge management. Knowledge management was defined based on the article "On Knowledge Management" by Ramon Barquin in the November/December 1999 issue of the *E-Gov Journal*: "Knowledge Management is the process through which an enterprise uses its collective intelligence to accomplish its strategic objectives."

Dr David quoted Bran Ferren, President of Walt Disney Imagineering who stated that no "big idea" would survive a requirements process. She asserted that Enterprise Knowledge Management is ***definitely*** a big idea, which requires the reinvention of the way we operate and that our requirements' processes and Program Objective Memorandum (POM) build cycles will not effectively support this. To successfully achieve this we need to focus on the four key elements critical to the success of Knowledge Management: Strategy, People, Process and Technology.

The strategy provides the motivation, or sense of purpose for the activity. Effective knowledge management requires a shared goal or objective — and the strategy describes the way that goal will be achieved. People are the next critical element. Without people who create and use the knowledge, the whole issue is moot. People, or participants in the enterprise, must be motivated to share not only information, but knowledge as well. That is, they must do more than simply populate databases and other static repositories. They must actively and personally engage in building and using the collective intelligence of the enterprise. And, these participants must span the spectrum from those who collect and analyze information to those who take action based on the results. That is, the traditional "customers" of the analytic community — whether they are warfighters, policy makers, law enforcement officials or local first responders — must be active participants, expanding the collective intelligence of the enterprise.

In terms of process, if Knowledge Management is defined as the overall process, then critical sub-processes include cooperation, communication and collaboration. Michael Schrage in *Shared Minds: The New Technologies of Collaboration* stated that the core processes must include robust cooperation, communication and collaboration. In his book, Mr Schrage defines cooperation as "people working together for a common purpose without necessarily having defined the purpose," communication as "the exchange of information" and collaboration as "an act of shared creation and/or shared discovery."

Finally, we must have the enabling technologies to make connections, from people to machines, between machines and among people. Computation can be quite powerful, but it is fundamentally stupid! Emerging adaptive algorithms hold the potential for moving from "what you ***ask*** is what you get" to "what you ***need*** is what you get" in searching for information. This type of smart search has the potential to save significant time and effort.

Mr Jim Johnson, Deputy Director for Theater Assessments and Planning, OSD, ODPA&E, discussed "Perspectives on Requirements Analysis." He emphasized the need to do a thorough job of analyzing the trade space to understand not only cost versus effectiveness but also the relationship of cost and risk.

Jim illustrated that the shape of the cost versus effectiveness curve in systems effectiveness analysis, when explored and well understood will reveal where this relationship may become very important to the analysis. For example, if maximum effectiveness as a function of cost is achieved very early in the system effectiveness curve and the application of added dollars has little effect in growing effectiveness, one may then focus on that part of the curve where dollars buy significant value.

Also illustrated was the notion of buying down risk. As in the system effectiveness case, risk may be related to investment. Investments in force structure are made in light of anticipated threats. US force structure reduces the threat of war or diminishes the risk of unacceptable losses if military operations are undertaken. Again, one must explore the analysis space to understand the shape of the curve or the surface. This will allow the study to identify the region where added investment ceases to diminish risk in a meaningful way.

To make results relevant he provided the following recipe aligned with Dave Robinson's questions:

The Question	The Answer
What is the question?	Keep it simple.
What is the real question?	Don't forget what you know.
What do the final slides look like?	Encapsulate complex representations.
What do I already know?	Know your audience.
How do I get the remaining information I need?	Be relevant.

Table 2. Making Results Relevant

Mr Bruce Powers, Director for Requirements Analysis, CNO Staff, N81, provided "Perspectives on Capabilities Analysis." He described the IWAR/CPAM process that the Navy uses to plan the way ahead so that decisions made today do not foreclose flexibility in the future.

Bruce identified the four primary components of the mission of the Deputy CNO for Resources, Warfare Requirements and Assessments:

- Analyze uses of the Navy, including its goals in operations, providing insight to CNO, SECNAV and DoD.
- Identify programmatic paths to provide required future capabilities.
- Clarify consequences of each path, and possible blockages (e.g., funding and technology).
- Keep at least one path open toward each operational goal.

A very interesting feature of the IWAR/CPAM strategy is to ensure that total lifecycle cost for systems and follow-on systems is accounted for. The Navy employs a far-reaching planning horizon to ensure that the Navy: "Develops alternative force structure paths at the platform level for ships, submarines and aircraft that meet fiscal constraints. Each path will attempt to maximize warfighting capabilities while balancing recapitalization, modernization and operating costs."

Bruce summarized by stating that in building the future Navy there is a need to assess what the Navy will be doing — how to make it the most capable. He emphasized that this must be done within projected cost constraints (e.g., zero growth) and in light of other considerations such as maintaining program stability, a strong industrial base, etc.

Mr Mike Yoemans, Chief Knowledge Officer, OSD, OASD (C3I), presented an overview of knowledge management during lunch on the first day of the workshop.

Mike described a framework for managing knowledge. Figure 1 illustrates this framework.

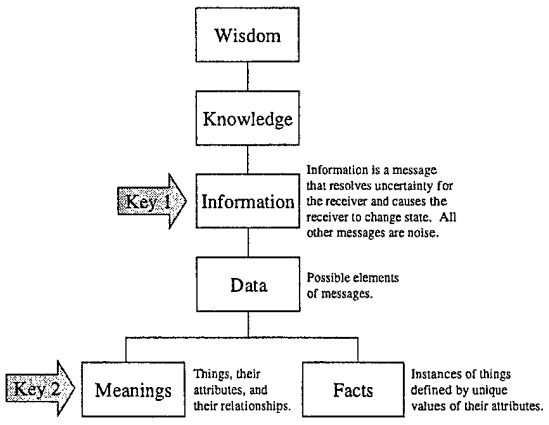

Figure 1. Epistemological Architecture

He emphasized the need to focus on how knowledge is constructed through a bottom-up process that accumulates facts and meanings in order to develop data. Knowledge is derived by

human beings who combine data with context. This may be understood by using the metaphor of a message. The message provides context and the data provides the combination of facts and meaning. Humans who take advantage of the knowledge they are able to accumulate have wisdom if they apply this knowledge in meaningful ways. This is a rather simple epistemology, however, it does provide a useful set of definitions and semantic relationships for discussions of Knowledge Management.
Mike went on to emphasize the need for a Global Information Grid (GIG) that currently does not exist as a necessity for achieving information superiority. One of the goals of ASD (C3I) is to promote the development of Knowledge Management and a skill-based workforce throughout DoD. A trusting environment where there is a need and the incentive to share information is essential to the success of knowledge management. To counter the popular saying that knowledge is power, he quoted ADM Harold Gehman. "Knowledge, jealously guarded by an individual, is not power. Quite the opposite, it detracts from the power and effectiveness of the entire organization." "We must adapt to new information flow. Everyone must "know" what everyone else knows."

Working Group Sessions

The workshop attendees were organized into four subject area WGs of about 20 to 30 members each plus a Synthesis Group to address the overall goals and objectives.

WG 1, Management of Analytic Knowledge, examined the manner in which analytic knowledge is discovered, expanded, organized and shared.

WG 2, Enabling Collaboration, examined the process, tools and techniques that support distributed analytic teams in performing analytic tasks.

WG 3, New Analysis Challenges, examined military operations analysis questions of interest for which the established military operations analysis community apparently does not have answers.

WG 4, New Analysis Tools and Methods, examined emerging developments in analytical approaches to complex systems to assess potential applications to challenging military operations analysis problems.
The Synthesis Group sought to discover the common themes that tie together the efforts of the four subject area WGs and provide feedback to the groups on a continuing basis.

In the following sections, the efforts and products of each of these five groups will be described in greater detail, sessions will be summarized and recommendations will be enumerated.

Working Group 1 — Management of Analytic Knowledge

Vision Statement: Informed decisions resulting from effective and efficient analyses enabled by the sharing, collaboration and creation of knowledge.

WG 1 examined four questions:

- How is analytic knowledge currently discovered, captured, expanded, organized and shared within the DoD analysis community?
- What Knowledge Management techniques can be applied to improve DoD analysis?
- What analytic practices (fast turn-around, deliberate, etc.) would make use of analytic knowledge?
- What recommendations do you have to improve the existing analytic practice using knowledge management?

This WG examined the literature that is defining the field of Knowledge Management. The group examined the manner in which analytic knowledge is discovered, expanded, organized and shared. It also addressed intelligent search engine technology and intelligent agent technology and how these techniques leverage

web-based stored data to meet real-time analysis requirements.

WG 1 Session Summary

Session 1 – Introduction to Topic; The Analytic Enterprise

Session 2 – Case Study on the Mobility Requirements Study; A Portal to Analysis Knowledge

Session 3 – A Conceptual Framework for Using Knowledge Management; Case Study Knowledge Management Lessons from the Synthetic Theater of War

Session 4 – DoD Practices for Acquiring and Storing Analytic Knowledge

Session 5 – Working Discussion

Session 6 – Working Discussion

Moving From "Siloed" to Enterprise Knowledge

The WG identified features of DoD organizations involved in analysis today, assessing that analytic knowledge tends to be protected as if held in a silo, accessible only to the organization holding the knowledge.

"Siloed" Knowledge	Enterprise Knowledge
Information "silos" determined by organizational boundaries, divisions, functions, etc.	Enterprise-wide integration of information resources.
Study centered	Issues centered – Information, people, tools, etc.
Navigation via operating and file systems	Navigation via hypertext browser links and search engines.
Reliant on internally generated information.	Integrates external information from strategic partners, suppliers, customers and third party sources.
Information shared via e-mail.	Information shared via knowledge portals.

Table 3. Contrasting Views of Knowledge Access

In contrast to this current state of "Siloed" Knowledge, the WG defined corresponding features of the desired state of enterprise knowledge where organizations can openly access knowledge from the entire analytic enterprise.

Lessons from the Private Sector

A study recently conducted by the Working Council for Chief Information Officers demonstrates that there are approaches already implemented in industry from which DoD may benefit. It should be emphasized that these are proven technologies and techniques. In fact, some of these technologies and techniques are either prototyped or in place in DoD. For example, both ASD(C3I) and US Joint Forces Command have implemented policies, techniques and technologies that are adapted from industry. These include:

Thesaural Browsers — These browsers generate lists of related terms and resources allowing users to take advantage of otherwise unexpected associations between seemingly unrelated information sources and types.

Personalized Intranet Portals — The creation of customizable intranet interfaces allows analysts selective access to information resources required to perform their jobs, enables analyst automation of simple, routine tasks and creates a vehicle for a central information-management body to "push" relevant content to distributed users in real time.

Cultural Change — Make collaboration and knowledge sharing a component of annual performance counseling and provide incentives (awards and commendations) for initiatives that improve collaboration and knowledge sharing.

Capture and Reuse Best Practices — Best-practice teams in analysis divisions or analysis units leverage their subject expertise to discover and codify best practices, which are then passed on to a corporate knowledge-management group that helps propagate the use of best practices across the enterprise

Information Expiration Mechanisms — Intranet content is automatically identified by date of creation and/or last modification; dated

documents are flagged and routed to their authors, who review them for relevancy and decide to archive, delete, modify or reinsert the documents back into the corporate database.

Content Validation Protocols — A process must be put in place to prevent the propagation of inconsistent or incorrect information throughout the enterprise.

A Strategy for Improving Operations Analysis in DoD

The strategy recommended by the WG to improve the practice of military operations analysis in DoD through the application of enterprise knowledge management is:

- The Joint Staff, J-8, and OASD (C3I), provide leadership in the development and implementation of policies that both enable and foster knowledge sharing and then follow through with the facilitation of change to realize knowledge sharing.

- OASD (C3I) take the lead to inform DoD leaders of the value to be derived from knowledge sharing in order to change the mindset of the leaders. Collaboration and knowledge sharing must be promoted within the leadership and the community to change the culture from protecting knowledge to sharing knowledge.

- DoD organizations and agencies must overcome the barriers to knowledge management implementation.

- OASD (C3I) develop policies and procedures that result in continuing education and training in knowledge management practices and technologies.

The DoD Sponsors should prototype collaboration and knowledge sharing processes for specific military operations analysis problems that may benefit from these approaches. These efforts should be used to illustrate, from the bottom up, the value of collaboration and knowledge sharing in evolving the practice of analysis.

Description and Discussion of WG 1 Findings and Recommendations

There are many obstacles to collaboration and knowledge sharing in the pursuit of military operations analysis in DoD. Policies that are currently in place make it impossible for us to use existing knowledge tools. The lack of a single coherent GIG or infrastructure precludes both technique and technology solutions that are tested and available. The pace of technological change is daunting; we need a plan and a framework for rational decision making that allows change to take advantage of marketplace innovation while mitigating the impact of change on organizations and their budgets. The analytic community must find the social or economic model that provides the incentives to individuals to share information. At its most fundamental level, collaboration and knowledge sharing will only be a success if it is obvious to the individuals involved that it is in their interest to participate. Organization and individual resistance to required change has to be overcome. There are individual and organizational incentives in place now that cause individuals to hoard information. Individuals use the information they have as a means to cement their importance. This is probably the single biggest hurdle that must be overcome. Change is hard; there must be something in it for each individual analyst to embrace the concepts for collaboration and knowledge sharing.

There is a need to standardize the practice of Military Operations Analysis, that captures those activities and procedures that are common to most analyses. Standard analytic practices facilitate collaboration and knowledge sharing by reusing proven methods and analytic product frameworks. Standard practices that may be accessed through the intranet or Internet also help resolve gaps in experience levels that may exist in an organization's analytic capability.

The need for security and the policies that enforce security are important, however, information security is probably the second

biggest (after individual resistance) stumbling block to improved analytical practice. We must make a very careful assessment of both the need for highly compartmentalized security practices (need-to-know) and the way in which these policies are implemented. The SECRET Internet Protocol Router Network (SIPRNET) is already challenging many of the old shibboleths. This is not to say we should be careless, but rather we must assess the payoff of greater sharing versus the risks associated with sharing. The rewards for sharing are lowered cost in terms of the time it takes to perform analysis. If speed of analysis is as important as our leadership insists it is, then barriers must come down.

WG 1 had thirteen specific recommendations arrayed across categories of Strategy, People, Process, and Technology. They are:

Strategy

- The DoD Sponsor should implement knowledge management techniques, particularly to establish an intranet portal, in support of an important study with suitable scope, schedule and content that partners DoD components MORS, industry and academia. The elements that should be considered along with strategy include people, process and technology.

People

- DoD and MORS lead an assessment of the capability to provide a baseline inventory of analysts for DoD operations research studies
- MORS assess its capability to establish a Knowledge Management Professional Development Program for the DoD Analytic Enterprise that would include the identification of skills and products, the refinement of skill levels, and the training of analysts.
- The DoD Sponsors evaluate successful skill-inventory systems (e.g. Northrop-Grumman and Y2K) for implementation within the DoD Analytic Enterprise.

Process

- J-8 accept leadership with OASD (C3I) of an evolving analysis process for the purpose of improving analysis in a future analysis state. Notionally, the evolving process could be closely interfaced with an evolving knowledge management process as shown in Figure 2.

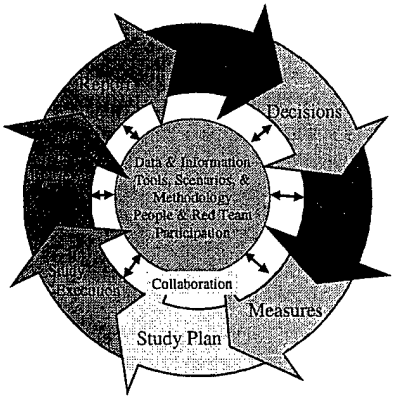

Figure 2. Interrelationships Related to Collaboration, Creation and Reuse

- DoD determine the business rules for contributing analytic knowledge. For example, what are the current rules that control the access to past studies and how could these rules be changed to improve access such as those stored at FFRDCs? A special case is the identification of the business rules for administering and controlling an analyst's portal.
- The DoD Sponsors, with the assistance of MORS, identify new types of information required for future analyses (e.g. foreign demographics, information warfare related, economic information, national infrastructure related, chemical/biological, etc.)
- The DoD Sponsors identify current centers of expertise required for improved analyses.
- The DoD Sponsors take steps to systematize the organization of information by using principles from traditional library and information sciences in the electronic realm.
- The DoD Sponsors, with the assistance of OASD (C3I), develop and use an

information architecture that structures the design of information organization, labeling, navigation and indexing systems to support both browsing and searching.

- The DoD Sponsors identify and use a set of metrics for the business case preparation and performance evaluation of the Analyst's Portal.
- The DoD Sponsors create knowledge-sharing incentives such as: Performance Reviews that emphasize collaboration and knowledge sharing and recognition for individuals show collaborate, share knowledge and otherwise support the organizations efforts in this area.

Technology

- DoD concentrate on applying Commercial-Off-The-Shelf (COTS) tools as a key critical success factor for building analytical Knowledge Management portal. Example technologies include:
  - Thesaural Browsers
  - Personalized Intranet Portals
  - Federated Knowledge Management
  - Information-Expiration Mechanisms

Working Group 2 — Enabling Collaboration

Vision Statement: Collaborative analysis is an analytic activity that involves the sharing of data, tools and expertise across organizational boundaries to achieve a common goal.

WG 2 examined four questions:

- How is collaboration currently used in the DoD analysis community?
- What formal and informal collaboration techniques can be applied to improve DoD analysis?
- What analytic practices (local study, centrally managed study, etc.) would make use of collaboration support?
- What recommendations do you have to improve the existing analytic practice using collaboration?

The working group participants determined that the first and third questions were very similar and combined their consideration.

WG 2 Session Summary

Session 1 – Current State of Collaborative Analysis

Session 2 – When, Where and What Kind of Collaborative Analysis is Desired?

Session 3 – Collaborative Analysis Policy Issues

Session 4 – Organizing for Collaborative Analysis

Session 5 – Emerging Techniques that Enable Collaborative Analysis

Session 6 – Locating Analysis and Subject Matter Expertise

Where Does Collaboration Exist in Analysis Today?

There are three principal types of analyses in which collaboration is a reality today. Analysis in the unified commands is collaborative by nature due to the military, political, inter-agency and international considerations. In this real-time environment, the decision-cycle is so compressed that analysis must be agile to be useful. If tools, data and talent are not available when called, the decision will be made without analytical insight. Analysts in US European Command (EUCOM) have learned, for example, that they are frequently asked to provide deployment and logistical analysis. Collaborative work is made more difficult by geographic separation and Operations Security (OPSEC) concerns.

Within the Beltway, collaborative analysis is frequently directed to answer Congressional Language or to support the Planning, Programming and Budgeting System (PPBS) decisions. In this environment, joint and service considerations pre-dominate. Unlike the environment previously described, these activities are important, but not so urgent that tools, data and skills cannot be massed and employed in a deliberate, formal way. A

distinguishing characteristic of this kind of collaborative work in a hierarchical oversight structure that guides the analysis from cradle to grave.

The third collaborative analysis type is the service/agency study performed to meet an internal requirement. Intra-service and inter-service collaboration is driven by the needs of the service customer. Analyses of Alternatives (AoAs), for example, for Acquisition Category I (ACAT-I) systems frequently require a joint context. Consultation and rendered assistance across organizational boundaries may be formal (by memorandum) or informal (by professional courtesy).

Formal and Informal Techniques that Enable Collaboration

Collaboration can be encouraged and assisted by both formal and informal mechanisms. One motivation for an organization to collaborate is to acquire the use of tools and expertise to meet infrequent requirements (e.g., support to Joint exercises or contingency plan development). EUCOM and the Center for Army Analysis (CAA) believe that this arrangement works best when working relationships have been established in advance and are rehearsed. In this way, the supporting organization understands the decision making processes of the supported organization and the hardware/software/security requirements for interoperability. While collaborative work can be done from a distance, EUCOM prefers on-site support. Co-location helps allay fears concerning operations security, responsiveness and miscommunication.

The existence of an "honest broker" for data encourages participants to share their data holdings. The Joint Data Support (JDS) Office has earned the trust of the Services, the Joint Staff and other offices in the Secretariat, by the way, it has controlled the data entrusted to it during Mobility Requirements Study 2005 (MRS-05). Perhaps more important than its role as a "gatekeeper," is the service JDS provides to the community by cross-checking the data it receives against other authoritative sources to identify data anomalies. These anomalies are provided back to the source for resolution, improving the veracity and consistency of DoD data holdings.

Informal trust-building activities like MORS and positive experiences with collaborative analysis help to overcome organizational and individual resistance to teaming.

It is important to remember that collaborative analysis is not an appropriate technique for all situations. A quote attributed to Napoleon is "I would rather fight allies than be one." Sharing common ends does not guarantee agreement on the ways and means to be used to get there. Group pressure to cooperate can result in compromises that preserve the status quo when what was really needed was creativity and a bold shift.

LTC Jerry Glasow presented a paper in the WG that classifies collaborative methods as being either "input-based" or "output-based." MRS-05 typifies the former while the Phased Threat Distribution (PTD) Study is an example of the later. The "input-based" approach reasons that if the participants accredit (1) the data, (2) the tools and (3) the analysts, the results will, in turn, be accredited. When this approach is implemented by a sequence of models (e.g., air defense precedes deployment precedes force-on-force evaluation) a single point failure can delay the entire project. It also tends to produce point estimates rather than a range of possible outcomes for consideration.

Two advantages of the "output-based" approach are parallel, independent analysis and multiple results that can be compared. The most difficult part of this approach can be determining why the results are different. If this approach is used, several integrated teams should be commissioned by the participants rather than putting the participants in competition with one another.

Data Collection and Production

Data collection, production, preservation and maintenance were recurring themes in the WG deliberations. Jim Methered, citing his experience during and after OPERATION ALLIED FORCE, is vehement that data collection must be a component of the Joint Task Force (JTF) information management plan instead of the "ad hocery" that exists today: "...scavengers picking over small, rapidly decaying, incomplete and questionable data and then fiercely defending the scraps gathered from others."

A potential major future role for operations analysis may be to study how information is used and develop ways of managing and using it better. Process engineering in peace might facilitate analysis in war as well as improve actual and simulated decision making processes.

Description and Discussion of WG 2 Findings and Recommendations

The working group recommendations are collected under three headings, people, process and products.

People

We must find ways to identify (and evaluate) subject matter experts to make access to such people fast and to provide confidence to the analyst that the SME they are in contact with is respected in the subject matter domain with which they are associated.

We must find a means to develop operational experience in Civil Service 1515s and uniformed analysts who do not hold warfighting specialties. The alternative is to find a way to integrate non-analyst operators in analysis efforts.

Process

There is a spectrum of collaborative analysis processes, and each has its strengths and weaknesses (bold shifts versus consensus).

- We can organize to perform competitive analyses to find new ideas.
- We can organize to search for a "common ground" solution. Collaborative analysis is a "team sport" and requires practice.

Operational Analysis support to Commanders in the field is most effective when a mindset of "Train as you Fight" is embedded in training and analysis practice. Ways must be found to re-establish formal liaison/exchanges to improve the quality of analysis.

Today, collaborative analysis takes longer to perform than analysis done in isolation. In the future, timelines can be shortened if informational exchanges and liaison between analytic organizations/agencies are institutionalized in our business practice.

In the short-term, it's important that we reconcile our demands for data with our ability to produce it. Dr Chris Lamb, ASD(S&TR), is currently leading an effort with the services and the intelligence agencies to better coordinate our efforts. It also makes good sense to plan in advance for the long-lead data that are common to many of the studies we do (e.g., Time-phased Force Deployment Data (TPFDDs)). In the long-term, data collection in the operational environment needs to evolve from something that interferes with task performance to something that is transparent to people performing their day-to-day tasks. Similarly, directives to perform large, collaborative analysis needs to be harmonized with the day-to-day analytic workload.

- Support independent, accredited sources for data to speed collaborative effort.
- Find ways to identify data to source new applications and phenomena.
- Data collection must be deliberate and done in such a way that it does not require additional effort by operators.
- Synchronize data production with data demands and institutionalize production and update of long-lead items (e.g., extend the Joint Munitions Effectiveness Manual (JMEM) to include developmental systems).

- Harmonize schedule of major collaborative projects and service workload.

Products

Compressed decision-cycles and the tendency toward using briefings rather than reports as deliverables has lessened our use of literature search and our discipline to thoroughly document what we do.

We need improvements in literature search capabilities, identifying work in progress that may affect the project at hand.
We must improve our study documentation techniques, allowing for reproducibility of results and reuse of data in addition to descriptions of our procedures and findings.

Working Group 3 — New Analysis Challenges

WG 3 examined a single focus question:

- What new military operations problems should the analysis community consider in its evolution of analytic practice? Or stated differently, what problems are not well served by the current state of the practice?

The working group examined military operations analysis questions for which the established military operations analysis community apparently does not have the answers. The working group was about new problems, problems not involving conventional warfare, and/or post-Cold War problems. Actually there are old problems that belong here as well. The issue isn't whether a problem is new or old, but rather whether the military operations research community has succeeded in addressing it satisfactorily. An example is the problem of determining the value of a common operational picture to the warfighter. Presentations to this working group came from the major analysis players such as the Services' Studies and Analysis shops, from warfighters like the US Joint Forces Command (JFCOM) and US Pacific Command (PACOM), and from decision makers like OSD, the Joint Staff and the Services' warfare requirements and assessment organizations.

WG 3 Session Summary

Session 1 – New Analysis Challenges

Session 2 – Challenges in Army Modeling

Session 3 – Analysis Challenges for Joint Operations - A USCINCPAC Perspective

Session 4 – New Analysis Challenges in Navy Programs and Fleet Battle Experiments

Session 5 – New Analysis Challenges in Air Force Programs and Logistics Analysis Challenges

Session 6 – Analytical Challenges of the USMC

Analysis Problems that are not Well-Served by Current Analysis Techniques or Approaches

With the end of the Cold War, the Department of Defense and thus the DoD analytical community, are faced with the demand of conducting and thus analyzing a variety of new operations. These new operations require new methods of analysis for planning, conceiving concepts of operations, defining doctrine, and analyzing effectiveness. Some examples of these new domains are:

- High Intensity/Low Casualty Conflict.
- Military Operations Other Than War (MOOTW).
- Humanitarian Operations.
- Peacetime Engagement.
- Operations in Urban Terrain.
- Technology Insertion (Digital Battlefield, Tomorrow's Dismounted Warrior).
- Chemical/Biological Warfare (Including Contagion).
- Asymmetric Threats (domestic terrorism, political manipulation, homeland defense).
- Special Operations.
- Information Operations/Warfare.

Problems with the Current Emphasis

The current emphasis on modeling and simulation with its resulting de-emphasis on other analytical tools and methods is limiting the analysis toolkit. With the amount of time and resources required for scenario development and data collection to run the current models and simulations, some other alternatives are clearly needed. For example, methods of scoping analysis that can quickly look at the alternatives and potentially set the stage for further, larger, study are needed. These scoping tools can serve to pare down the alternatives and allow the focus on the important question to evolve. In addition, simpler analysis tools such as spreadsheets should be used and exchanged within the analytical community as a rapid means of knowledge transfer. Finally the analyst should be taught to combine the results from all pertinent tools and analytical methods to more thoroughly, accurately and quickly answer the question at hand.

With the increasing complexity of today's military scenarios and high technology weapons, there is a greater need for the analysis community to be able to identify and communicate the effects of the factors and their interrelationships. It is especially important to be able to conduct and communicate the trades conducted between factors that typically would not be linked. For example, an aircraft carrier can be the platform used for Joint Strike Fighter (JSF) launches, and a typical analysis may look at the number of targets put at risk by various sizes of JSF fleets. However, an interrelated measure that should be considered is the deck space that is being taken up by the JSF fleet, that may potentially be used for such things as helicopter medical evacuation (MEDEVAC) support, two very important missions with interrelations that must be considered.

There are many factors that effect the outcome of a battle, but do not have directly measurable combat effects. These factors must be taken into account, and their effects must be traced to operational and strategic outcomes. These factors include such things as:

- Logistics.
- Bandwidth requirements.
- Engagement/presence on PERSTEMPO and OPSTEMPO.
- Infrastructure investments.
- Readiness postures.
- Various force structure alternatives.

The behavior of individuals, small units and adversary leaders must be captured in our evolving analytical tools. The effect and measurement of behavior factors at the individual or small unit levels are important considerations, especially in the analysis and evaluation of combat systems. For example, the increase in situational awareness for the individual foot soldier is probably a good thing to a point, until information overload occurs or if the equipment used to give the situational awareness decreases the individual's effectiveness in other areas, such as mobility. On the other hand, being able to quantify the characteristics and motivations of an adversary leader would allow the identification of the leader's or country's centers of gravity and may assist the planning process in identifying effective target sets that would influence the enemy's course of action.

Methods for quantifying risks of all sorts must be developed and institutionalized.

The frequency of calls for quick-turn around analysis is increasing. These analyses take many forms, such as support for testimony to Congress or support to ongoing warfighting efforts. To answer these types of questions, the analyst needs a set of tools that support these quick analysis activities. These tools need to capture the important elements that would be drawn out by more thorough analysis but run quickly enough to support answering the question when the answer will still be desired and relevant.

Description and Discussion of WG 3 Findings and Recommendations

There were three broad recommendations that were defined by WG 3.

- As the analytical community evolves, it needs to find tools to deal with new forms of operations, find methods to trace known factors and interactions to their logical combat output, and find tools that will provide accurate and thorough analysis in a short timeline.
- The DoD analytical community needs to nurture analysts and emphasize analytical thinking rather than focusing on simulation and modeling development. The community must project a more balanced view of model capabilities as well as limitations, and reverse the recent trend toward blind faith toward large models as the solution to all analytical problems.
- The analytical community needs to find means for characterizing and communicating the impacts of uncertainty. For example risk, such as decision risk based on the fact that various factors may not have been considered in the current analysis, need to be characterized and communicated to the decision maker.

Working Group 4 — New Analysis Tools and Methods

WG 4 examined four questions:

- What currently emerging developments in analytical approaches to complex systems can be applied to challenging military operations analysis problems? Consider areas such as chaos, complexity theory, etc.
- To what DoD analyses, particularly the new analytic challenges defined by WG 3, can these approaches be applied?
- What recommendations do you have to improve the existing analytic practice in the near term by using new analysis tools and methods?
- What recommendations do you have for areas of research for the next generation of military operations analysis?

The New Analysis Tools Working Group sought to identify emerging tools and techniques for conducting operations analysis, given the new challenges that face the military operations research community in the 21st century.

To accomplish this, MORS leadership assembled representatives from domains that are not normally part of the traditional MORS population. Experts with expertise in Command, Control, Communications, Computers and Intelligence (C4I) systems, intelligence, policy analysis, artificial intelligence and knowledge management were present. This eclectic set of skills resulted in information exchange that exceeded expectations, a vision focused on providing a foundation of consistent and compatible data, as well as an architecture that could provide connectivity between command and control systems and analytic modeling environments.

The kinds of connectivity and consistency that are envisioned in this product are believed to be absolutely essential for providing commanders and staffs in the field with flexible automated planning support, and keeping analysis relevant in the highly uncertain future that the DoD faces.

Perhaps most importantly, it was concluded that for the most part there is no technological impediment to achieving the vision that is articulated herein, and that these kinds of efforts are an essential part of achieving the knowledge management "culture" that has been implemented successfully in many commercial enterprises.

WG 4 Session Summary

Session 1 – Mapping "New Tools" to "New Needs"

Session 2 – Joint Warfare System, Joint Modeling and Simulation System, Land Formation Model

Session 3 – Army Modeling and Simulation Office, Army Artificial Intelligence Center, Joint Data Support

Session 4 – C4I Model, Project Albert and Operational Synthesis and DTI

Session 5 – Mapit and Dynarank

Session 6 – IWEDA and Terrain Modeling

Assumptions and Scope

Because the solution space within which the working group was operating the group made initial assumptions to bound its discussions. In some cases the assumptions were found to be too restrictive and were later relaxed.

The first assumption is that Knowledge Management experts will create a repository infrastructure, and that infrastructure will be available for use to store and distribute analysis domain knowledge.

Analysts within DoD have been modeling and simulating for a long time. There is an existing set of recommendations in the DoD Modeling and Simulation Master Plan. These recommendations are assumed to be good, and future recommendations should deviate only when needed.

There are architectures available to us to move information that would be in a knowledge management oriented system and culture. Discussion with experts from the C4I domain revealed that the assumption does not hold with respect to the Defense Information Infrastructure Common Operating Environment (DII COE) standards.

The Analysis Functional Working Group of the DoD Executive Committee for Modeling and Simulation (EXCMS) has a valid list of analysis deficiencies that needs to also be considered. The WG focused on how to do big studies better and then began to look at minute-long decision cycles (from WG 3) to balance out the discussions.

Analytical Requirements

Although warfare doctrine and military missions are evolving, there are constant / recurring analytic requirements that can and should be planned for:

- Force assessment.
- Planning and execution.
- Deliberate planning.
- Crisis action planning.
- System effectiveness and trade off analysis.
- Concept and doctrine development and assessment.

These missions are fairly constant in the workspace of military operations research. There is ever reason to believe they will continue to be the main missions of the future. They form the space around which to structure the new tools for analysis challenges.

Because the group began deliberation at the same time WG 3 was meeting, a generic set of decisions that could be supported by analysis was used to stimulate discussion. Over the course of the workshop, the group considered WG 3 inputs as they arrived.

One notable possibility that was added by the C4I domain was the existence of decision aids that are either currently embedded, or planned for in near real-time command and control systems. These systems would benefit from analytically sound underlying algorithms and the group felt strongly that the analysis community would need to be an active part of their development.

Accomplishing these analytic missions requires descriptive tools (models and simulations), prescriptive tools (choice and resource allocation), reliable and consistent data.

A significant body of work is underway in the DoD that advances the state-of-the-art in modeling "infrastructure." This work seeks to correct deficiencies inside mission areas. However, it fails to capitalize on related work

(schedule and resource constraints). This results in inefficient and inconsistent modeling and analysis efforts.

A Knowledge Management Framework for Analysis

During the conference, we saw the knowledge management framework (the dark gray or blue boxes) as a hierarchy of knowledge products built on the base of known facts and derived meanings as shown in Figure 3.

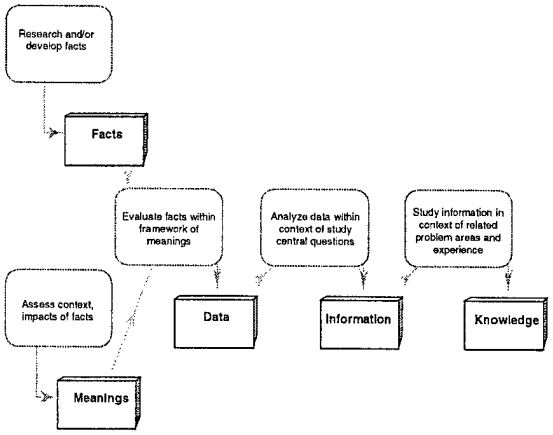

Figure 3. Analysis Process in the Context of Knowledge Management

One of the insights from our work is that the application of knowledge management within the analysis community is actually a process of becoming conscious of the importance of building and sharing the knowledge of our analysis enterprise — both subject area and analysis expertise.

The analysis process (shown in light gray or yellow) produces knowledge products. The essence of analysis has always been to create knowledge from the raw materials of facts and meanings.

One aspect of wisdom — the highest level knowledge product shown in the original framework (and missing from the far right side of this diagram) — results from continuing to develop and use analysis capabilities over time.

Figure 4 provides a slightly different view of the analysis process and products from the previous slide. It highlights the product areas that the working group might consider as areas for improvements.

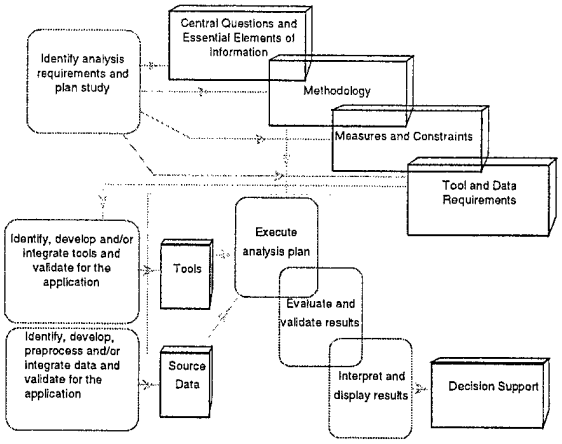

Figure 4. Analysis Process Alternative View

Much of the discussion centered on tools and data, particularly the need to integrate information generated from multiple tools, sequence data flows from one tool to another, and to ensure that the data objects were consistent such that they could be used as is or logically transformed to meet modeling requirements. The term "model," defined in the broadest sense as the abstract representation of any problem, was frequently discussed as a key tool.

Another emphasis area was to reduce the data-to-tool-to-information cycle time sufficiently to meet the needs of the customers with very short decision timelines. Traditionally, these customers have relied on back-of-the-envelope estimates, "quick and dirty" analyses, to offer insights to support decisions. Since these decisions are frequently high-level and wide ranging, the analysis community would like to design tool and data solutions that offer both a high quality and timely response.

Decision support needs centered on visualization tools — the ability to clearly represent complex decision spaces, dissimilar tradeoffs and the like — that have not yet been identified. The group identified knowledge management practice as

the preferred solution option to identify and reuse methodologies and measures.

An Architecture of Systems, Software and Models to Support Analysis

The group developed an "architecture" of systems, software and models that was perceived to be necessary to meet the needs of military leaders, and defense managers in the twenty-first century. This architecture is shown in Figure 5. The kinds of unprecedented connectivity and consistency that are envisioned are required to keep analysis and analysis products relevant inside the short decision cycles that are emerging. It is also necessary to achieve a culture of "Knowledge Management" in which the system of systems we are attempting to analyze has achieved a complexity that is beyond the comprehension of any one person or discipline.

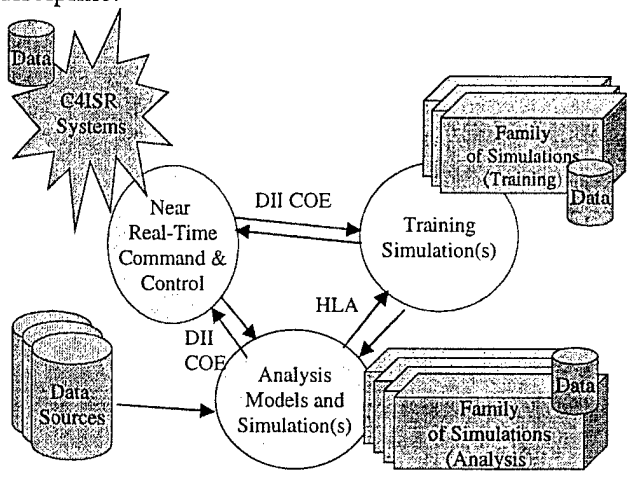

Figure 5. The Future "Framework" for Analysis

There are three primary nodes in this network of systems. First, there are near real-time C4ISR systems. Operational planners and commanders who are tasked to execute the nation's military missions use these systems. In the "information age" military, they exist in some form or another from the National Military Command Center (NMCC), down to the soldier in the foxhole. The second node is analysis models and simulations. These models and simulations, ranging from simple spreadsheets and decision tables to large theater simulations are used to develop and evaluate plans, choose courses of action, and manage the DoD. The final node envisioned consists of training simulations. Again, these simulations vary in scope and complexity.

All of these nodes have a common requirement. They all need data (both primitive and meta) to function. If we are to achieve the envisioned interoperability it is absolutely essential that this data be logically consistent, and portable across domains when desired.

One fact that emerged is that the C4I community is embedding decision aides into emerging command and control systems. These decision aids are effectively models that operational staff members and commanders will use to make decisions on those short timelines we see emerging. It is important that analysts (and others) be involved in the development of these algorithms to increase the likelihood that the underlying logic is sound and consistent. Moreover, this kind of involvement is necessary if the DoD is to achieve its objectives with respect to the reuse of software, and achieve a more cost effective maintenance stream for models and data of all types.

In theory the DII COE standards provide vehicle for data communication from live systems to simulations. However, it was learned that the communication between the C4I and analytic communities will not support this objective. Moreover, there are inconsistencies between the C4I and training domains.

An example illuminates how this system would improve our operational decision making. Envision a requirement for PACOM to deploy humanitarian assistance to East Timor. There is a need to provide logistical infrastructure to rebuild or secure this nation. Also, assume the planning process produced a contingency plan that includes identification of the forces that would be sent on this mission.

The plan and all of its assumptions have been described in some analysis model (perhaps in an Operations Plan (OPLAN) Format) and reside in data. At the time the requirement to execute is identified, the data in the plan are compared to

ground truth data. The army database on current forces identifies the fact that the 25th Supply and Transportation Battalion which was in the plan is not available because it is deployed. And, the US Transportation Command (TRANSCOM) data shows that the C-5s that are necessary to meet the timeline are committed to some other high priority mission. What has happened is that we have used existing data to quickly illuminate assumptions that were valid at planning time, but are not at execution time. Operators are then quickly able to focus on managing the exceptions.

The deliberations in the group revealed that there are fundamentally no significant technological impediments to achieving this vision. The obstacles are largely related to achieving a sound common data model, and developing a cultural will to expose data to other domains.

Description and Discussion of WG 4 Findings and Recommendations

The working group had five broad recommendations associated with the analysis of new tools and methods for analysis.

- Increase DoD emphasis on supporting inter-service collaboration toward standards. This builds on the existing service efforts. Existing organizational models include the Joint Technical Coordination Group's (JTCG) (JMEM) and the Modeling and Simulation Resource Repository (MSRR) Board of Directors. This should include Joint rules for reconciliation of standards. A baseline should be established (i.e. a minimal standard for meta-data).
- Use the accumulated but limited experience as a foundation for analysis knowledge management implementation. Establish a formal plan for achieving the vision including senior leader support and involvement, a deliberate investment strategy, and one that uses the multi-disciplinary team. There should be a co-evolution of culture and funding for technology.
- The analysis community should be represented in the DII COE process. The DII COE standards should be impacted by requirements that emanate from the analysis community.
- DoD should develop and resource a strategy for collecting "other source" data, and applying knowledge management. Other source data include National Training Center (NTC) exercise data, historical deployment data and lessons learned data.
- Encourage the creation and use of "quick and dirty" tools. This should be accompanied by: the development of rules of the road for using data, the accumulation of best practices and mechanisms for timely peer review, the use documentation and allowance for evolution.

The Synthesis Group Report

Vision Statement: Since analysis is both a product and a process, our vision is a re-emphasized and revitalized practice of analysis to more effectively and more efficiently connect the decision maker and analyst so that the final product is not the primary result.

The Synthesis Group included members from each working group and met daily with the chairs and co-chairs of those groups. This was done to both highlight common areas and to request effort on specific topics that would help the Synthesis team in their efforts to create a follow-on action plan to help the military operations research community achieve the overall vision of the conference.

Toward this end, the Synthesis Group asked each WG to articulate a vision that would capture the end state resulting from full implementation of their group's recommendations. Based on their inputs, the Synthesis Group articulated its own Vision Statement. The Synthesis Group believes this vision transcends and incorporates the subject area working groups' visions and describes how emerging capabilities such as collaboration and knowledge management can transform the practice of military analysis. The emergence of

powerful communication and computer-based capabilities is already changing the economic world. Where before the focus was on production, the emerging giants of e-commerce are now succeeding through their acquisition and management of information. The most successful and most profitable of these businesses are those that enable the highest level of information sharing, so that opportunities are quickly identified, decisions made based on the full amount of information and insight available in the work force, and then action initiated appropriately. The knowledge resident in every worker is rapidly connected to the decision makers so that timelines are reduced and customer needs satisfied, optimizing company effort and taking full advantage of the knowledge base of the organization. In a like manner, military analysis in the future will need to be fully integrated, with analysts and decision makers so closely linked through technical and personnel means that the maximum benefit will flow to the organization. In fact, the interaction will be such that the final results of any study will surprise no one, since decision makers and analysts will both be engaged throughout the analytic process, allowing the strengths and insights of each to be fully incorporated. Such a construct will revitalize the practice of analysis, take advantage of the emerging capabilities, and better address new challenges confronting analysis in the new millennium.

The Tool and Challenge Matrix

The products of WG 3 and 4 analysis were combined in Figure 6 to illustrate what new or emerging tools and techniques show promise to address, at least in part, the challenges identified by WG 3.

Those challenges fell into six broad categories:

- Changing characteristics of warfare in the 21st Century (New Wars).
- Inclusion of the effects of humans and human factors (e.g., moral, training, etc.) into models (Behavioral).
- Showing the effect of logistics and other support activities on warfighting outcomes (support).
- Identification of complex interrelationships between input variables and between internal variables (processes) within models (interactions).
- Explicit quantification of risk and uncertainty in analysis and in communications with decision makers (risk).
- The challenge of developing and gaining acceptance of analysis techniques that are not dependent upon traditional simulation or other models (e.g., linear programs) (non model).

TOOLS	CHALLENGES					
	New Wars	Behavioral	Support	Interactions	Risk	Non-Model
1. Collaborative Standards	x		x	x		
a. Army Std Category Coord	x		x	x		
b. Conceptual Modeling &MSSR	x		x	x		
2. Automated Data Generation	x		x			
3. Analysts Rucksack	x	?	x		x	x
4. Commercial Analysis Tools		x			x	x
5. Advanced Modeling Concepts						
a. Agent-based Simulation		x		x	?	
b. Fusion models	x	x			x	x
6. Multi-discipline team	x	x		x	x	x
7. Implementation of KM	x	x	x	x		x
8. Environmental MSEA			x	x	x	
9. "Other Source" Info by KM	x	x	x	x	x	x
10. Research on Automated Decisions		x	x	x	x	x
New Wars = Methods for analyzing new domains of Warfare						
Behavioral = Inclusion of behavioral factors in current models						
Support = Measure combat impact of support (Log, C4ISR, OPTEMPO, Readiness etc)						
Interactions = Identifying complex interrelationships between factors						
Risk= Quantification of risk and uncertainty						
Non Model= Reduce the model centricity of analysis						

Figure 6. Tool / Challenge Matrix

WG 4 identified many recommendations regarding new or emerging tools and techniques that should be explored and implemented where appropriate. These tools and techniques fell into ten categories as shown in Figure 6.

The first category listed involves standards. There are some relatively new efforts underway to develop common standards that can be applied to the models and data used to support analysis; the Army Standards Category Coordination process is one example of this. Defense Modeling and Simulation Office (DMSO) -sponsored efforts to develop common conceptual models and the MSRR are other examples. The group recommended that the fundamental algorithms underpinning many

major simulations in use be examined in open (peer review) forums and reconciled. Although a commonly accepted set of algorithms would be desirable, it is not necessary that all services or other users agree to a single representation of a warfare phenomenon. We can agree to disagree, provided the differences are clearly documented and understood and made available to the analysis community.

The second technique identified by WG 4 is automated data generation. The biggest single complaint from the WG was the lack of needed data and the difficulty and cost of generating or obtaining data even when it is available. Automated means of generating commonly used data would increase the responsiveness and reduce the cost of getting the data.

The "Analyst's Rucksack" is an example of using quick and simple tools and decision aids to fill in for large model deficiencies and directly support warfighters. The Workshop endorsed the development of tool sets of this nature.

The commercial world is also producing an array of tools that have great utility for operations research analysts. Tools which have been around for several years, but are becoming increasingly sophisticated and easy to use, include statistical and data analysis packages, linear and nonlinear programming, process simulation and decision analysis software. Emerging products include neural networks, Bayes nets, colored petri nets and other software that propagate inferences or influences.

There is recent research that is producing some new techniques that may be applied to fix, in part, some of the areas that lack tools for analysis. Agent-based simulation may help in the analysis of doctrine, procedures and risk sensitivity, and recent mathematical models have been developed to assist in the simulation (and real-world execution) of fusion between multiple sensors and sensor disciplines. This is not an exhaustive list, but these are two areas that show promise.

Performing analysis in the 21st century will likely lead to the resurgence of the multi-disciplinary team. However, this team will have a different composition that the teams in the early days of military operations research, which were largely formed from hard sciences. Although some problems may still require physicists, chemists, etc., most work will require groups pulled from three broad areas. The first consists of domain experts, which will often include warfighters, doctrinal experts and other expertise in military operations. The second group is software and computing experts, as models and tools become increasingly complex from a software perspective. The third group, which helps to meld the other two together, consists of operations research analysts and other experts from related analysis domains, such as mathematics and statistics. We should no longer expect that a single military operations research analyst be able to read and write code, develop mathematical models and possess a broad military background to include joint operations.

The implementation of knowledge management techniques identified by WG 1 and presented by plenary session and lunchtime speakers will also help address the challenges to the practice of military operations research. These concepts are developed in detail in other sections of this report.

Modeling and Simulation Executive Agents (MSEA) have, in some areas, greatly advanced the state of the art in modeling and simulation (M&S). The environmental MSEAs have had a great degree of success and can serve as exemplars of the process that leads to significant improvements. They have developed data standards applicable to a wide variety of simulations (to include both training and analysis simulations) and real world command and control systems, and populated these data structures with data that is easily obtained through user-friendly business processes. They have also developed algorithms to transform the data into information useful to aggregated models; for example, the Army has developed techniques for automatically generating road networks from detailed NATO-standard mobility networks.

One area that can be addressed through good knowledge management practices involves "other source" information. This data includes NTC exercise data, historical deployment data and "lessons learned" data. These data sometimes exist but are not necessarily recorded for posterity (e.g., much NTC information is outbriefed to the unit commander and then deliberately destroyed), not captured at all (e.g., historical deployment data), or are captured only qualitatively rather than quantitatively (e.g., lessons learned). These data, if resources are applied for capture and storage, can significantly improve our ability to validate models against "real world" experiences.[3]

Finally, the group recommended that additional research be made in the area of automated decision making. Large simulation models require some automated representation of a human decision maker (e.g., a commander and staff in an analysis model or an opposition force (OPFOR) or subordinate commander in a training model) to provide reproducibility or reducing exercise/training costs. However, the current implementations are recognized to be insufficient and unrealistic. Automated decision making can also be embedded in real-time decision aids, not to replace a human decision maker but to advise him or her.

Analysis to Support Decision Making

Figure 7 illustrates one view of the current practice of analysis.

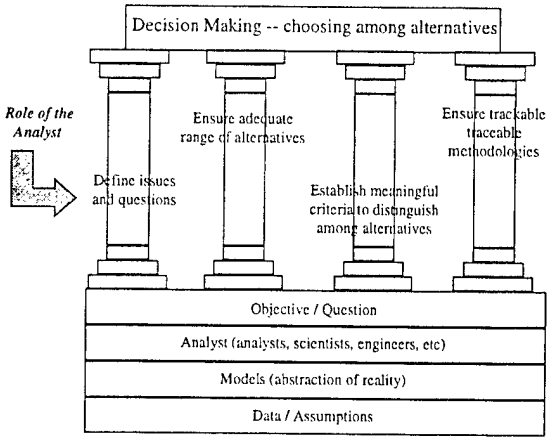

Figure 7. Analysis to Support Decision Making

It shows that analysis is focused on one goal: helping decision makers choose among alternatives. The four activities analysts support in this practice include:

- Helping the decision maker define the issue or questions.
- Helping to define the decision space so that a full range of alternatives can be considered.
- Establishing meaningful measures of effectiveness and criteria that will help show the strengths and weaknesses of the various alternatives.
- Then creating understandable, traceable and repeatable methodologies that will assist in this selection process.

To do this, an analytic foundation must be in place. This foundation includes:

- People who contribute to the process, primarily analysts, but including a broad range of other scientists, engineers and SMEs.
- Models, or the concepts, mathematical abstractions or other constructs that are used to decompose a problem and focus on key aspects.
- Data, scenarios, assumptions and other factors that are necessary to support the process.

[3] It is recognized that exercise data is not real combat data, but it is useful surrogate data that may be more accurate than outputs from abstract models and simulations.

The issue addressed by this workshop is how this framework is, and will be, impacted by the changes in the national security and technological landscapes and how the practice of analysis should evolve to handle the challenges and take advantage of the opportunities provided by these changes.

Of course, the very complexities presented by the rapidly changing landscapes associated with this environment may have removed the ability for analysts and others to focus on the big picture. The new environment as assessed by WG 3 presents a conundrum: we are asked to provide insight on the complex interrelationships between factors input to and within our models (that reflect interrelationships in the real world), but we are also asked to reduce the complexity and increase the transparency of our tools and analysis. Although it may not be possible or necessary to reduce the complexity of our high-end models (recognizing of course that not all analysis requires large and complex models), open sharing of model data, assumptions, algorithms, etc., all within a set of agreed-upon standards and implemented through knowledge management, may increase the transparency of the models and analysis process *among trained analysts*. The analyst will always have to convert complex mathematical and structured logic into forms understandable to a decision maker without an operations research background in all but the simplest cases. Thus, an elegant solution may not be a reduction in complexity to a handful of variables, but instead be a transparency and sharing among analysts that is communicated to the decision maker throughout the analysis (rather than at the end) in a clean and direct (if not elegant) manner.

At the same time, there are potential solutions available, at least to address part of the changing environment, and to help our analytic community and other parts of the DoD enterprise to adapt and prevail in the emerging environment of the 21st century. Dr Ruth David, the first keynote speaker for this workshop, defined Knowledge Management as:

- The process through which an enterprise uses its collective intelligence to achieve strategic objectives. Furthermore, Knowledge Management is realized through strategy, people, process and technology.

Inherent in her definition was the understanding that the enterprise using knowledge management was a "lean, mean, fighting machine" team focused on common objectives and with a shared understanding of the necessity and value of each other's contribution. Such a definition of enterprise may not reflect the current state of DoD, where mutual contributions are not recognized and parochialism can break down teamwork. However, to the extent that shared goals and teamwork reflect DoD, and in the areas that knowledge management can help the department move toward this enterprise vision, the department should surely embrace knowledge management and its implementation.

Certain aspects of knowledge management can already be endorsed in ways that do not threaten existing culture. In particular, knowledge management has the ability to help us distinguish between what we know and what we don't know by helping the enterprise quickly tap the collective knowledge of the individuals in the organization. Done correctly, such a capability will allow an individual assigned to work a problem the capacity to poll all experts in or out of the organization to assess what might already be known or what is in the process of being studied about the problem. Rather than wasting time reinventing wheels, a properly implemented knowledge management system will save enormous time and resources by helping the analyst and others rapidly determine what is already known as the basic starting point of any study. The same system, by enabling rapid connectivity between analytic practitioners will also enhance information sharing and collaboration. When one study team, already focused on a specific area, realizes that the value of its research can be increased by adding just a small amount of effort in order to address a broader range of questions and meet the needs of a broader customer base, one promise of knowledge management will be realized. In fact, as the limited resources available in an organization self-organize to focus on the areas they do best in order to provide a broader base

of insight and information for the organization, the people involved will clearly understand that their value-added is not in developing and hoarding information, but rather in sharing information in ways that enhance the overall capabilities of the enterprise. Value-added comes not from having information since in today's world information will be available to everyone. The value instead comes from the ability to use available information in new and creative ways to enhance the capabilities of the organization.

Returning to our analytic construct, we can see that changes in the national security landscape are already shaking some of the analytic pillars. Evolving from attrition-based warfare to effects-based warfare, understanding the implications of Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) systems and capabilities, and the emergence of a broad new array of asymmetric threats are all impacting the ability of the analytic community to develop reasonable measures of effectiveness as well as to develop clear and repeatable methodologies to assess these aspects of military activity.

While these areas are outlined with the dashed lines (which appear in red in color versions of Figure 8), the technological landscape and emergence of new capabilities like knowledge management are impacting the rest of the words to potentially transform the way we conduct analysis.

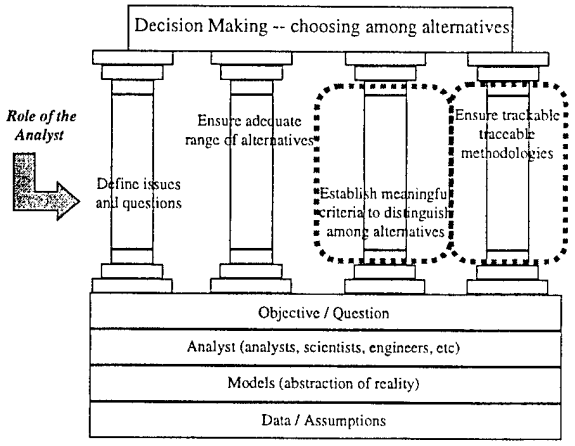

Figure 8. Emerging Pressures

Figure 9 provides more detail on the changes, with the circled "national security landscape" reflecting the circled area on Figure 8. We've already hinted at the changing paradigm of massed armies meeting on a battlefield to the massing of effects at the appropriate time and place as the way current US military leadership is starting to think about warfare. In fact, to help think through the implications of such changes, MORS has conducted a number of workshops and will hold a C4ISR Follow-on Workshop in the fall to continue to evolve our understanding in this arena.

- National Security Landscape
  - Massing forces -> massing effects (C4ISR follow-on meeting)
  - Environmental - Threat (World is changing - are we?)
  - Ash Carter & Bill Perry (A/B/C Lists from the QDR Workshop)
  - Technology Insertion
  - QDR 2001 (strategy - ???)
- Technology Landscape
  - Knowledge Management
  - Collaborative Analysis Management
  - Commercial Initiatives

Figure 9. Challenges

Some of our speakers in this workshop have referred to the Ash Carter/Bill Perry work on who the threats of the future are. They range from an A List of direct threats to national survival which would include homeland attack by catastrophic terror agents, to a B List of threats to national interests that the current strategy seems to address, to a C List of important problems that do not threaten US vital interests (e.g. Kosovo, Somalia). In addition, new technologies require new analytic capabilities to measure the effects and potential contributions from such areas as directed energy, information technologies, unmanned systems and space. The QDR process may change the national military strategy, so the analytic profession will need to be responsive both in helping to determine the implications of strategy shifts as well as in implementing any new strategy in the analyses of the future.

Just as the national security landscape is changing, so is the technology landscape in which analysis is conducted. This workshop has highlighted knowledge management and collaborative capabilities, but there are a number of other initiatives, such as simulation-based acquisition and other e-commerce activities that the analytic community needs to track and adopt where it makes sense to do so.

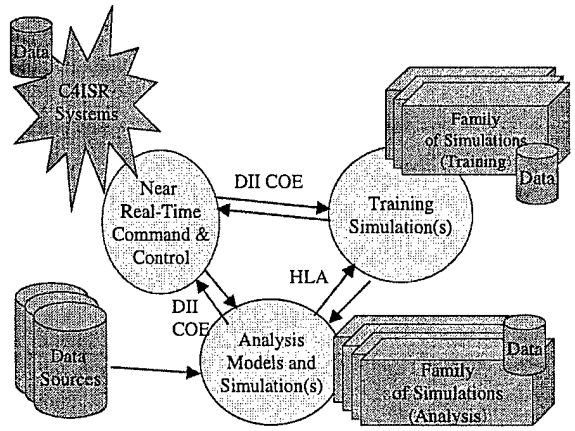

Figure 10. Potential Future "Framework"

Figure 10 shows an illustration of an ideal end-state for the current efforts to improve analytical practices. There are three families of models and simulations: M&S embedded in real-time command and control systems; training and exercise support simulations; and models and simulations used to support analysis (to include Test and Evaluation (T&E) analysis and analysis of non-warfighting issues such as infrastructure and business process improvement). Within each domain are a set of models and simulations tailored to the purpose at hand. No single model will apply universally across all domains, but in this ideal end state we have data, software objects and process representations shared across the domains where it is logically consistent with the model and purpose.

Infrastructure programs currently under development are assumed to be in place in this end state, to include the High-Level Architecture (HLA) for simulations and the DII COE linking all areas together. HLA federations, which may include simulations widely, distributed over space, will exist where appropriate, but these federations should be standardized and validated for consistency across federates before use. The creation of "on the fly" federations that grab objects and federates scattered across the DII to create unique environments is probably still not possible in this end state because there is no guarantee that the representations will be internally consistent (consistency is not assured even if data is passed through HLA), and it is unlikely that a single analyst or team located at a single site will be familiar with all of the objects or federates potentially available. Instead, these simulations may be combined through the use of collaborative analysis rather than software linkages.

All of the tools are presumed to be in a bed of warm data. That is, there is a data infrastructure that makes data readily available (with exhaustive metadata explaining the derivation and accredited use of the data) for all of these systems. For example, an analysis of real-world capability should be able to draw on the same data set showing current status and deployments of units that a real-time command and control system might use. Similarly, an analysis of a future capability (for example, a 2010 force in a particular scenario) should be able to draw on a validated and commonly used set of data to represent the scenario, system performance, OPFOR performance, etc. Generation and storage of this data requires a significant resource commitment within DoD, but it is necessary to achieve the desired end state.

A key feature of this environment is that the output of the models, as well as the results of specific analyses and the lessons learned from training and exercises are also added to the common database. This provides a useful source of information that can be of particular help to quick turn-around analyses, which may synthesize the outputs of previous models, exercises and analyses.

The Action Plan

The Synthesis Group identified a number of actions that should become part of a long-range action plan that the community should consider and flesh out over the next few years as it evolves the practice of military analysis in DoD.

There are several steps that MORS itself can implement immediately that have little work impact but enormous potential to improve the ability of this community to connect with each other and better meet the over all needs of its membership. In addition to the items listed below, the working groups provided a number of general and specific steps that will help the community learn to harness knowledge management and collaboration as well as to address emerging issues in the changing security environment. Generalized recommendations endorsed by the workshop include working the people, process and technology problems in order to ensure a better final product.

Actions for MORS include:

- Near Term:
  Update the MORS membership directory and database with more information on each member.

  Evolve the role of the Electronic Media Committee to address enterprise knowledge management.

  Contribute to a Code of Best Practices for Analysis and Joint Experimentation.

- Mid Term:
  Undertake focused workshop activity on this topic.

- Far Term:
  Use the Education Colloquia to address ideas that Knowledge Management is an important element of Professional Development

Actions for DoD include:

The working group recommendations provide a phased approach to knowledge management and collaboration implementation by focusing on people, process, technology and product, as well as list challenges and promising tools and methodologies to meet those challenges.

Table 4 summarizes the focus and potential impact of the specific actions recommended.

Summary Recommendations
Vision/Policy: Develop and promulgate an Enterprise Vision and strategic directions.
Culture: Take action to remove deeply rooted cultural barriers (e.g., remove the incentives to hoard knowledge)
Organization: Ensure that there is buy-in by Top Management. Investigate organizational constructs including business rules that best enable global collaboration of military analysts.
People: Provide incentives to analysts to collaborate and share knowledge.
Process: Institutionalize processes to enhance collaboration and the sharing of tacit and explicit knowledge among the analytical community.
Analytic Tools:
• Develop and emphasize joint standards in algorithm and data development.
• Expand the development and maintenance of data warehouses.
• Focus basic research and tool development to meet emerging challenges

Table 4. Summary Recommendations

First, cultural changes are a necessary prerequisite to effective transformation of the analysis community (e.g., the need to dispel the myth that "knowledge is power"). Second are several organizational issues that must be addressed. One of these is to ensure top management buys in to this transformation. Another includes reassessing how security issues can be addressed in an information-centric, open environment. In the third area, decision makers must recognize that the analysts involved in all phases of the assessment process constitute a critical intellectual resource.

They must be given incentives to stimulate them to contribute and draw from future knowledge warehouses. Tying all this together are the links between the vision and the high level guidance to the analysis process and the primary products of that process (i.e., effective, timely, rigorous analyses). To implement this linkage, a set of enhanced processes is needed (e.g., institutionalized processes to diffuse tacit and explicit knowledge) supported by a broad set of tools (e.g., knowledge warehouses, collaboration tools). These processes and tools are constrained by available resources (e.g., funds, manpower)

such that a special funding mechanism may be required to satisfy time-urgent joint needs. In particular, basic research must be continued in those areas where understanding of phenomenology is not available (human decision processes, Information Operations/Information Warfare (IO/IW), etc) as well as the continuing development of analysis tools to address the emerging challenges.

The Synthesis Group feels that by addressing the needs of the community to implement our vision, the practice of analysis can evolve from its current position of a limited toolkit and methodologies to address a limited number of issues to a complete tool set connecting analysts and decision makers to address the full array of national security challenges.

This workshop has demonstrated that there is great potential to be realized from the harnessing of the knowledge in our heads and in the systems that support our analytical efforts. In addition, there is great power in undertaking a more collaborative approach to the analyses that we perform. The combination of enterprise knowledge management and collaboration can deliver better analysis products faster.

Summary

The way ahead to realize this vision will be difficult. Nothing less than a cultural change is required. The demands of the national security environment require that we find ways to alter the information security environment to permit knowledge sharing and collaboration on an enterprise scale. Getting analysts to collaborate and breaking down the barriers to that collaboration and knowledge sharing are fundamental changes that require bottom up as well as top down change.

The members of this workshop acknowledge the potential value of such change. It is now up to us to obtain the buy-in of the DoD leadership by convincing them that the benefits are worth the investment of time, money and energy to realize the vision articulated by this workshop.

Appendix A: Acronyms

ACAT I	Acquisition Category I
AFSAA	Air Force Studies and Analysis
AoA	Analysis of Alternatives
ARL	Army Research Laboratory
ASD(C3I)	Assistant Secretary of Defense for Command, Control, Communications and Intelligence
ASD(S&TR)	Assistant Secretary of Defense for Strategy and Threat Reduction
C4I	Command, Control, Communications, Computers and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CAA	Center for Army Analysis
CEO	Chief Executive Officer
CINC	Commander in Chief
CNO	Chief of Naval Operations
CONOPS	Concepts of Operations
COTS	Commercial-Off-The-shelf
CPAM	
DII COE	Defense Information Infrastructure Common Operating Environment
DMDC	
DMSO	Defense Modeling and Simulation Office
DUSD (P&R)	
EUCOM	US European Command
EXCMS	Executive Committee for Modeling and Simulation
FBE	Fleet Battle Experimentation Program
FFRDC	Federally Funded Research and Development Center
GIG	Global Information Grid
HLA	High Level Architecture
IO	Information Operations
ISR	Intelligence, Surveillance and Reconnaissance
IW	Information Warfare
IWAR/CPAM	
IWARS	
IWEDA	Integrated Weather Effects Decision Aid
J-8	Director, Force Structure Resource and Assessment
JDS	Joint Data Support
JFCOM	US Joint Forces Command
JMEM	Joint Munitions Effectiveness Manual
JSF	Joint Strike Fighter
JTCG	Joint Technical Coordination Group
JTF	Joint Task Force
KM	Knowledge Management
M&S	Modeling and Simulation
MEDEVAC	Medical Evacuation
MOOTW	Military Operations Other Than War
MORS	Military Operations Research Society
MRS-05	Mobility Requirements Study – 2005
MSEA	Modeling and Simulation Executive Agents
MSRR	Modeling and Simulation Resource Repository

NATO	North Atlantic Treaty Organization
NMCC	National Military Command Center
NTC	National Training Center
OA	
OASD(C3I)	Office of the Assistant Secretary of Defense for Command, Control, Communications and Intelligence
ODPA&E	Office of the Director for Program Analysis and Evaluation
OMFTS	Operational Maneuver From The Sea
OPFOR	Opposition Force
OPLAN	Operations Plan
OPSEC	Operations Security
OPTEMPO	Operations Tempo
OSD (PA&E)	Office of the Secretary of Defense (Program Analysis and Evaluation)
PACOM	US Pacific Command
PERSTEMPO	Personnel Tempo
POM	Program Objective Memorandum
PPBS	Planning, Programming and Budgeting System
PTD	Phased Threat Distribution
QDR	Quadrennial Defense Review
SECNAV	Secretary of the Navy
SIPRNET	SECRET Internet Protocol Router Network
SME	Subject Matter Expert
T&E	Test and Evaluation
TPFDD	Time-Phased Force Deployment Data
TRANSCOM	US Transportation Command
WG	Working Group

Appendix B: Working Group and Synthesis Group Reports

Working Group 1: Management of Analytic Knowledge

Working Group 2: Enabling Collaboration

Working Group 3: New Analysis Challenges

Working Group 4: New Analysis Tools and Methods

Synthesis Group

MORS Workshop

Evolving the Practice of Military Operations Analysis in DoD

Working Group #1
Management of Analytic Knowledge

Chair: Michael Yoemans

Co-Chair: Gary Coe

February 29, 2000 through March 2, 2000

Naval Postgraduate School, Monterey, CA

Working Group #1 Members

Mr. Michael Yoemans	OASD(C3I)	Chair
Mr. Gary Coe	IDA	Co-Chair
Mr. John Black	JFCOM	
Ms. Joan Conover	JFCOM	
Ms. Mary Margaret Evans	OSD Reform Initiative Office	
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Dr. Jeffery Schofield	IDA	
Mr. Jack Sheehan	DMSO	

Working Group 1 Presentations

- Mr. Michael Yoemans, *Introduction to Knowledge Management*
- Mr. Gary Coe, *The Analytic Enterprise*
- Mr. Robert Graebener, *KM Lessons from STOW*
- Mr. John Black, *A Vision of an Analytic Portal*
- Mr. Jack Sheehan, *DMSO Initiatives to Identify, Access and Store Knowledge*

WG #1 Management of Analytic Knowledge Focus Questions

- How is analytic knowledge currently discovered, captured, expanded, organized, and shared within the DoD analysis community?
- What Knowledge Management techniques can be applied to improve DoD analysis?
- What analytic processes would be impacted by the implementation of Knowledge Management?
- What are the obstacles in successfully implementing Knowledge Management to the DoD Practice of Analysis?
- What recommendations do you have to improve the existing analytic practice using Knowledge Management?

WG #1 Management of Analytic Knowledge

The Workgroup's Vision

Informed Decisions resulting from effective and efficient analyses enabled by the sharing, collaboration and creation of knowledge.

WG #1 Management of Analytic Knowledge

The Strategy

- DoD Leadership by J-8 and OASD(C3I) to establish policies and facilitate change.
- Change the mindset of senior leaders and culture in DoD to promote collaboration and knowledge sharing.
- Partnering of appropriate DoD organizations and agencies to overcome the barriers to knowledge management implementation.
- Continuing education and training in knowledge management practices and technologies.
- Prototyping of knowledge management implementation to important problems to evolve solutions.

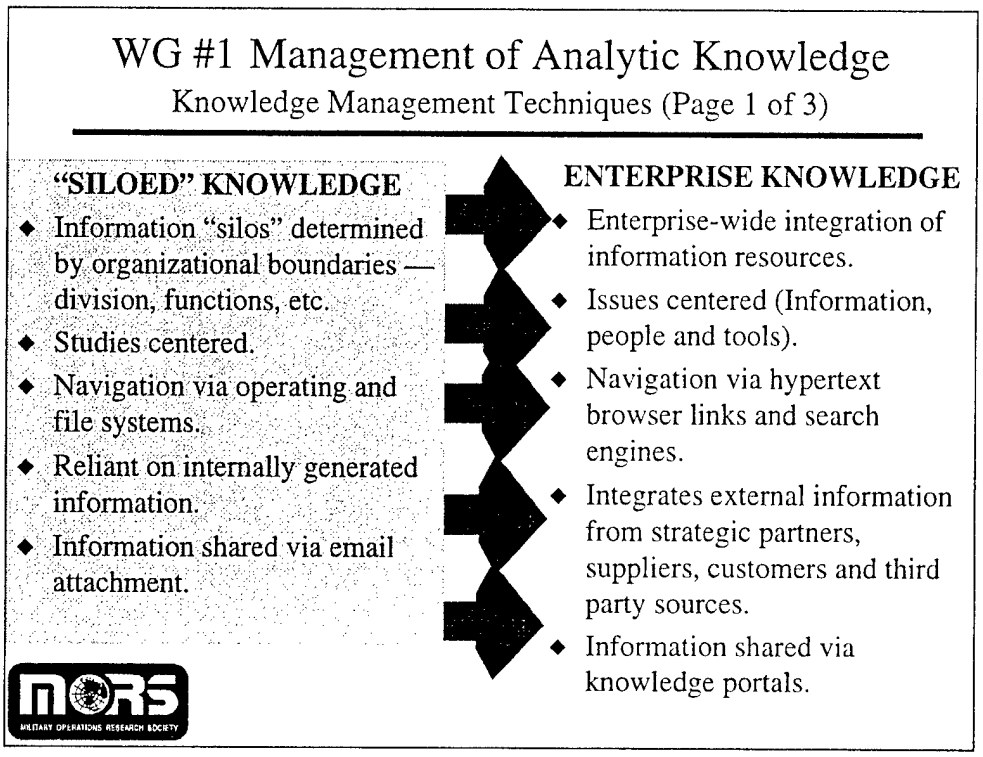
WG #1 Management of Analytic Knowledge

Current Use of Analytic Knowledge in DoD Analysis Community

"SILOED" KNOWLEDGE

- Information "silos" determined by organizational boundaries —division, functions, etc.
- Studies centered.
- Navigation via operating and file systems.
- Reliant on internally generated information.
- Information shared via email attachment.

Current analysis is done in-house using information available inside the organization. Existing information sources are designed to meet functionally oriented information needs — not for doing operational analysis.



As contrasted by the status quo in a knowledge organization analysts would use, or have access to, enterprise-wide knowledge repositories and should be issues oriented, leveraging the evolving technologies that permits board navigation of the knowledge-base.

WG #1 Management of Analytic Knowledge

Knowledge Management Techniques (Page 2 of 3)

Private Sector

- THESAURAL BROWSERS

  Browsers generate lists of related terms and resources, allowing users to take advantage of otherwise unexpected associations between seemingly unrelated information sources and types.

- PERSONALIZED INTRANET PORTALS

  The creation of customizable intranet interface allows analysts selective access to information resources required to perform their jobs, enables employee automation of simple, routine tasks and creates a vehicle for a central information-management body to "push" relevant content to distributed users in real time.

- KNOWLEDGE SHARING INCLUSIVE PERFORMANCE REVIEWS

  Incorporation of a knowledge-sharing into the corporate culture with incentives.

Industry has provided the models that DoD can leverage. A study recently done by the Working Council for the Chief Information Officers demonstrates this point. WG #1 included a copy of this material as a part of their proceedings.

WG #1 Management of Analytic Knowledge

Knowledge Management Techniques (Page 3 of 3)

Private Sector

- FEDERATED KNOWLEDGE MANAGEMENT

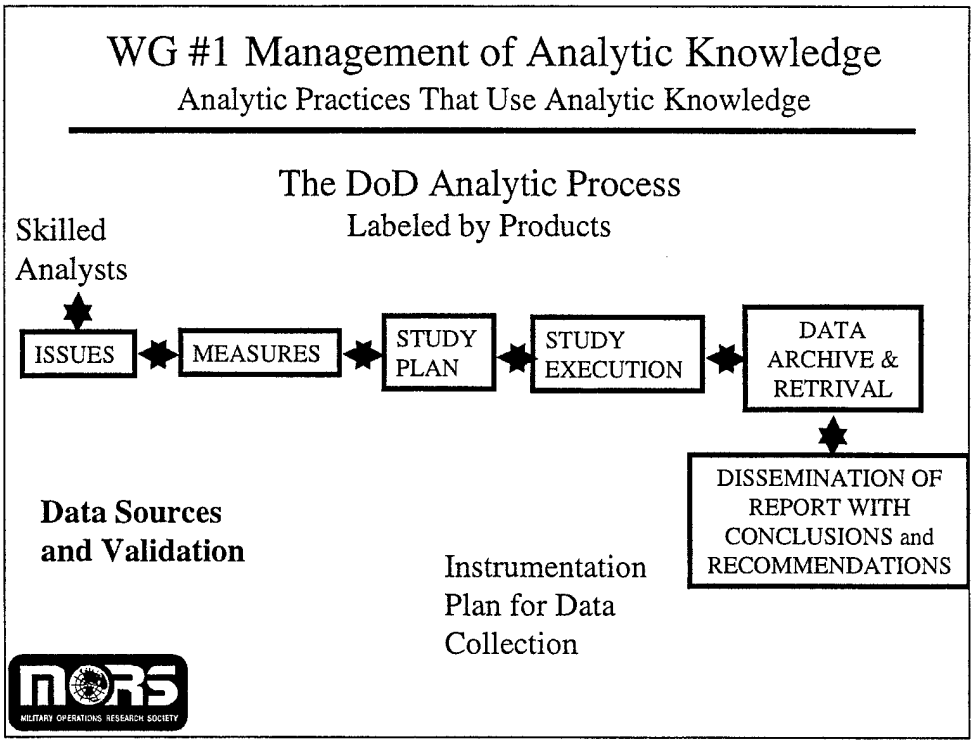
  Best-practice teams in analysis divisions or analysis units leverage their subject expertise to discover and codify best practices, which are then passed on to a corporate knowledge-management group that facilitates the propagation of best practices across the enterprise.

- INFORMATION-EXPIRATION MECHANISMS

  Intranet content is automatically identified by date of creation and/or last modification; dated documents are flagged and routed to their authors, who review them for relevancy and decide to archive, delete, modify or reinsert the documents back into the corporate database.

- CONTENT-VALIDATION PROTOCOLS

  A process to prevent the propagation of inconsistent or incorrect information throughout the enterprise.



In order to implement Knowledge Management (KM) to the DoD Analytic Process, we need to have a common understanding of this complex process. This was the working groups (1&2) consensus and all agreed that such an understanding was critical to successful application of KM practices.

WG #1 Management of Analytic Knowledge

Obstacles to Implementing Knowledge Management

- Policy makes it impossible to use existing knowledge tools.
- There is no Global Information Grid.
- The pace of technological change is high.
- No economic model that provides the incentive for sharing.
- Organizational and individual resistance.
  - Resistance to change.
  - What's in it for me?
  - Is this "too hard"?
  - The institutional incentive to hoard information and knowledge.
- The Challenges of Managing Unstructured Information (e.g. analyses).
- The need for security and protection of information in the conduct of many analyses.
  - The value of intellectual property.

The working group envisioned a number of major obstacles that would need to be overcome in order to implement KM successfully throughout the analytic community. This slide shows the important problem areas that the working group tried to address in their recommendations. These obstacles were carefully considered in the formulation of the strategy that the working group recommended in implementing KM to the analytical community.

WG #1 Management of Analytic Knowledge

Recommendations (Page 1 of 7)

- The DoD Sponsor implement knowledge management techniques, particularly to establish an intranet portal, in support of an important study with suitable scope, schedule, and content that partners DoD components Military Operations Research Society, industry, and academia. The elements that should be considered along with strategy already discussed include:
  - People
  - Process
  - Technology

This is our overarching recommendation, which detailed in the next series of slides under the headings of:

Strategy

People

Process

Technology

Specific organizations that should be included are the Services, OASD(C3I), DTIC, MSIAC, DMDC and DMSO.

WG #1 Management of Analytic Knowledge

Recommendations Page 2 of 7

- People
  - DoD and MORS lead an assessment of the capability to provide a baseline inventory of analysts for DoD operations research studies
  - MORS assess its capability to establish a Knowledge Management Professional Development Program for the DoD Analytic Enterprise that would include the identification of skills and products, the refinement of skill levels, and the training of analysts.
  - The DoD sponsor evaluate successful skill-inventory systems (e.g. Northrop-Grumman and Y2K) for implementation within the DoD Analytic Enterprise.

Slide 14

Industry experience and DoD case studies show that people is one of the most critical success factors associated with KM. The recommendations cited here are designed to provide the fundamental foundation for organizing and educating people using KM techniques being applied by industry. Key DoD organizations that could be involved in pursing this recommendation include ASD (C3I), DUSD(P&R), OSD(PA&E), and DMDC.

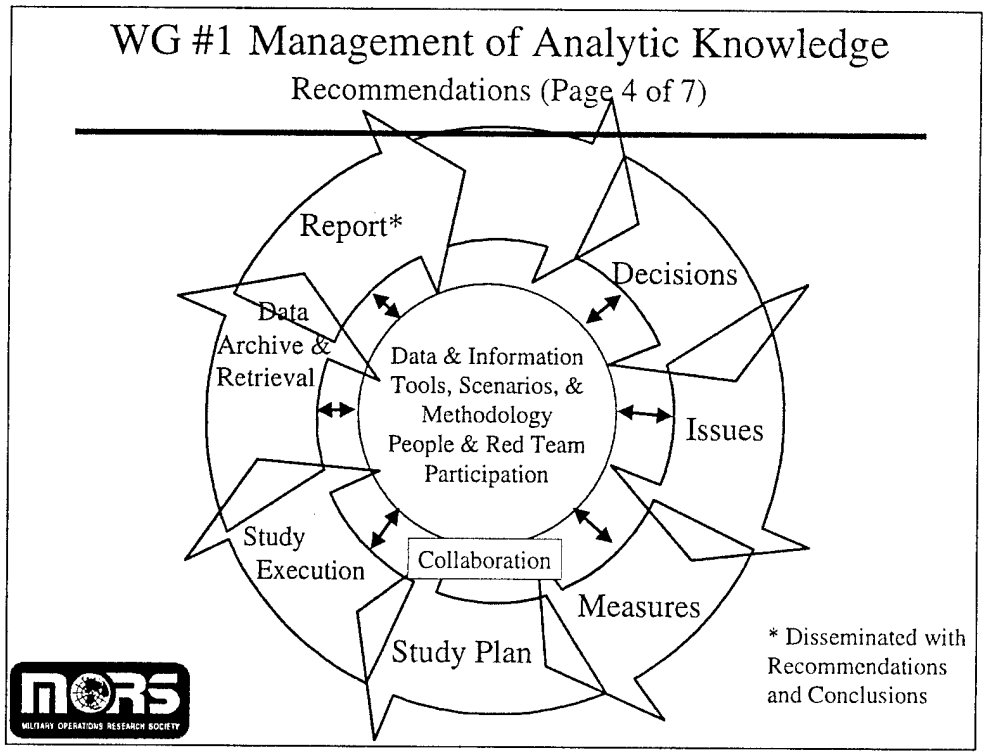
WG #1 Management of Analytic Knowledge

Recommendations (Page 3 of 7)

- Process:
  - J-8 accept leadership with OASD(C3I) of an evolving analysis process for the purpose of improving analysis in a future analysis state. Notionally, the evolving process could be closely interfaced with an evolving Knowledge Management Process as shown on the next slide.

Skilled Analysts

Instrumentation Plan for Data Collection



The working group recognized that the future (to-be) process incorporating KM is still to be defined. Nevertheless, this slide helps illustrate the important interrelationships related to collaboration, creation, and reuse of a well constructed analytical KM environment and extensible knowledge-base.

WG #1 Management of Analytic Knowledge

Recommendations (Page 5 of 7)

- Process continued:
  - The DoD determine the business rules for contributing analytic knowledge. For example, what are the current rules that control the access to past studies and how could these rules be changed to improve access such as those stored at Federally Funded Research and Development Centers (FFRDC). A special case is the identification of the business rules for administering and controlling an analyst's portal.
  - The DoD Sponsor, with the assistance of MORS, identify new types of information required for future analyses (e.g. foreign demographics, information warfare related, economic information, national infrastructure related, chemical/biological, etc).
  - The DoD Sponsor identify current Centers of Expertise required for improved analyses.

The working group concluded that the first bullet was probably the most critical follow-on task for J8 and ASD (C3I) to tackle. If this is not done KM will fail.

WG #1 Management of Analytic Knowledge

Recommendations (Page 6 of 7)

- Process continued:
  - Take steps to systematize the organization of information by transposing principles from traditional library and information sciences to the electronic realm.
  - Develop and use an Information Architecture that structures the design of information organization, labeling, navigation, and indexing systems to support both browsing and searching.
  - Identify and use a set of metrics for the business case preparation and performance evaluation of the Analyst's Portal.
  - Create Knowledge-Sharing Incentives such as:
    - » Knowledge-Sharing inclusive Performance Reviews
    - » Embedded Authorial Recognition

The importance of performance reviews and embedded are mentioned repeatedly in the literature. The study done by the Working Council for the Chief Information Officers strongly supports this point. This study also stressed the importance of having an information architecture for effective design and administration of browser-enabled knowledge-based repositories.

WG #1 Management of Analytic Knowledge

Recommendations (Page 7 of 7)

- Technology
  - The DoD concentrate on applying COTS tools as a key critical success factor for building analytical KM portal. Example technologies include:
    - » Thesaural browsers
    - » Personalized Intranet Portal
    - » Knowledge-Sharing Inclusive Performance Reviews
    - » Federated Knowledge Management
    - » Information-Expiration Mechanisms

MORS Workshop

Evolving the Practice of Military Operations Analysis in DoD

Working Group #2
Enabling Collaboration

Co-Chairs:
COL Robert D. Clemence, Jr.
LtCol Kirk Yost

February 29, 2000 through March 2, 2000
Naval Postgraduate School, Monterey, CA

WG 2 Participants

COL Bob Clemence	JCS/J-8	Chair
LtCol Kirk Yost	JCS/J-8	Co-Chair
Dr. Tom Allen	IDA	
Ms. Robbin Beall	CNO/N816	
LTC Jerry Glasow	DUSA(OR)	
Dr. Dan Fox	RAND	
Mr. John Bordeaux	ITT Research	
Maj Dan Zalewski	OSD/PA&E	
Dr. Richard Ryberg	LOGICON	
Mr. Jay Wilmeth	LOGICON	
Ms. Annie Patenaude	SAIC	
MAJ Sue Romans	CAA	
Dr. Louis Moore	RAND	
Ms. Elaine Simmons	JDS	

Fourteen experienced analysts from government, the FFRDCs, and industry participated in the eight working group sessions and should be given the credit for the contributions I will present.

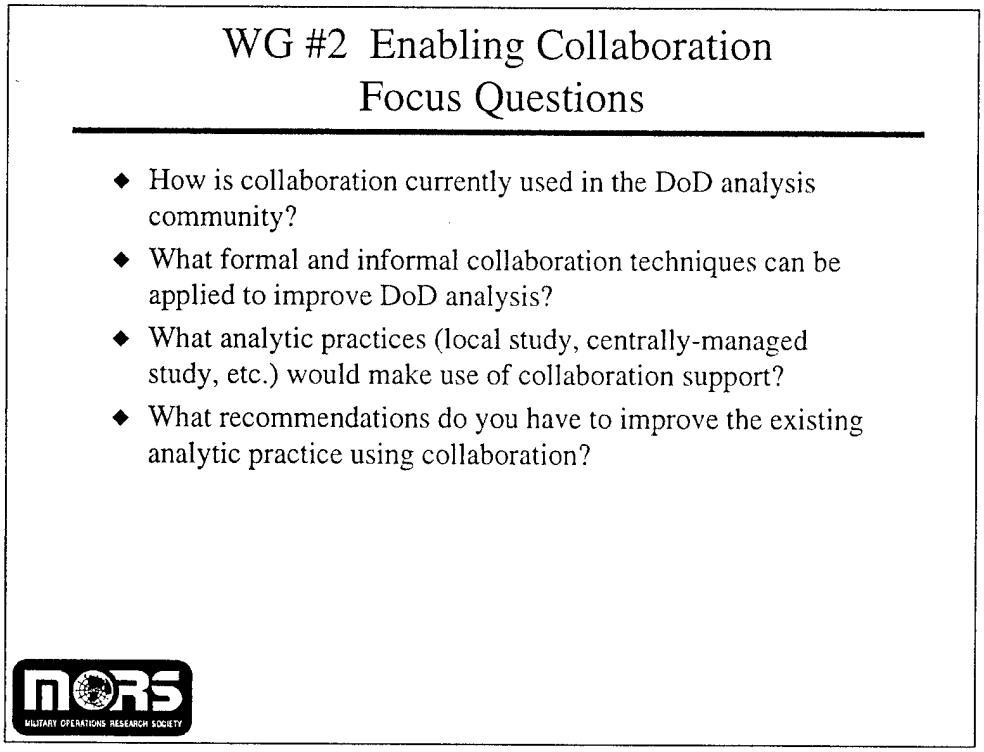
For our purposes, we have defined collaborative analysis to be any analytic activity that involves the sharing of data, tools and expertise across organizational boundaries to achieve a common goal.

WG 2 Presentations

- COL Bob Clemence, JCS/J-8, *Joint Analysis: A Status Report*
- LtCol Kirk Yost, JCS/J-8, *Organizational Alternatives for Collaborative Analysis*
- COL Jim Methered, EUCOM, *The Future of Joint Analysis: An Empirical Look for Lessons*
- LTC Jerry Glasow, DUSA(OR), *Input-Based vs. Output-Based Collaborative Analysis*
- MAJ Sue Romans, CAA, *Real Time Analysis*
- Ms. Elaine Simmons, JDS, *Resolving Data Issues in Collaborative Analysis*

We used contributed papers to motivate discussions on issues that individuals and organizations must confront before, during and after collaborative work, such as:

- When is collaboration useful?
- How should collaborative effort be organized?
- If information is power, how readily will organizations share their data?



Four focus questions were proposed before the Workshop to guide discussions. In our deliberations, we could not make a distinction between questions #1 and #3. The remainder of this presentation will address questions #1, 2 and 4.

WG #2 Enabling Collaboration

Current Use of Collaboration in DoD Analysis Community

- CINC analyses to support current operations:
  - Collaborative by nature but much more complex than in past.
  - National, International and Joint considerations.
  - Compressed decision cycle - come as you are (HW, SW, data, skill-set).
  - Event driven and spontaneous.
  - Limited by lack of forward analyst presence (few collaborators available).
  - Frequent requirement for Deployment and Logistical Analysis.
- DoD level analyses to answer congressional language or support PPBS:
  - Collaboration is directed.
  - Joint and Service considerations pre-dominate.
  - Results important, but not urgent - time to acquire tools, data and skills.
  - Formal process - Terms of Reference, Study Plan, Oversight.

We have identified three archetype analytic activities where collaborative analysis takes place.

Analysis in the unified commands is collaborative by nature due to the military, political, inter-agency, and international considerations. In this real-time environment, the decision-cycle is so compressed that analysis must be agile to be useful. If tools, data, and talent are not available when called, the decision will be made without analytical insight. Analysts in EUCOM have learned, for example, that they are frequently asked to provide deployment and logistical analysis. Collaborative work is made more difficult by geographic separation and OPSEC concerns.

Within the Beltway, collaborative analysis is frequently directed to answer Congressional Language or to support PPBS decisions. In this environment, joint and service considerations pre-dominate. Unlike the environment previously described, these activities are important, but not so urgent that tools, data, and skills cannot be massed and employed in a deliberate, formal way. A distinguishing characteristic of this kind of collaborative work in a hierarchical oversight structure that guides the analysis from cradle to grave.

WG #2 Enabling Collaboration

Current Use of Collaboration in DoD Analysis Community

- Service analyses to support acquisition, PPBS and doctrine development:
  - Collaborative when analysis is set in a Joint context.
  - Service considerations predominate.
  - Collaboration may be formal or informal.

The third collaborative analysis archetype is the service/agency study performed to meet an internal requirement. Intra-service and inter-service collaboration is driven by the needs of the service customer. Analyses of Alternatives (AoAs), for example, for Acquisition Category I (ACAT-I) systems frequently require a joint context. Consultation and rendered assistance across organizational boundaries may be formal (by memorandum) or informal (by professional courtesy).

WG #2 Enabling Collaboration

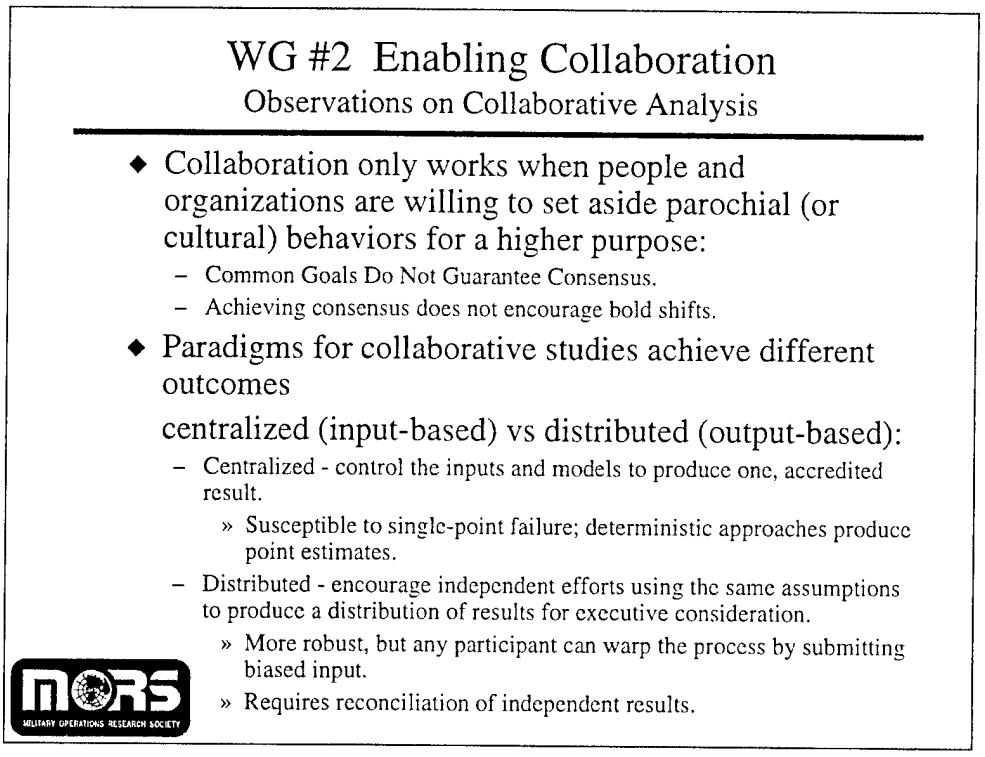
Formal and Informal Techniques That Enable Collaboration

- Direct Analytical Support:
  - Example: Deployment from CAA to EUCOM to support exercise.
  - Not responsive enough for crisis action planning.
  - Working relationships (organizational, personal) established in advance and rehearsed.
  - Co-location is preferred to tele-presence.
- Data Warehousing:
  - Trusted agent for data verification, validation and archival.
  - Adherence to formal data access and release procedures.
- Trust-Building Activities:
  - Participation in MORS working groups, workshops, etc.
  - Positive experiences with earlier collaborative work.

Collaboration can be encouraged and assisted by both formal and informal mechanisms. One motivation for an organization to collaborate is acquire the use of tools and expertise to meet infrequent requirements (e.g., support to Joint exercises or contingency plan development). EUCOM and Center for Army Analysis believe that this arrangement works best when working relationships have been established in advance and are rehearsed. In this way, the supporting organization understands the decision making processes of the supported organization and the hardware/software/security requirements for interoperability. While collaborative work can be done from a distance, EUCOM prefers on-site support. Co-location helps allay fears concerning operations security, responsiveness and miscommunication.

The existence of an "honest broker" for data encourages participants to share their data holdings. The Joint Data Support (JDS) Office has earned the trust of the Services, the Joint Staff, and other offices in the Secretariat by the way it has controlled the data entrusted to it during Mobility Requirements Study 2005 (MRS-05). Perhaps more important than its role as a "gatekeeper" is the service JDS provides to the community by cross-checking the data it receives against other authoritative sources to identify data anomalies. These anomalies are provided back to the source for resolution, improving the veracity and consistency of DoD data holdings.

Informal trust-building activities like MORS and positive experiences with collaborative analysis help to overcome organizational and individual resistance to teaming.



It is important to remember the collaborative analysis is not an appropriate technique for all situations. A quote attributed to Napoleon is "I would rather fight allies than be one." Sharing common ends does not guarantee agreement on the ways and means used to get there. Group pressure to cooperate can result in compromises that preserve the status quo when what was really needed was creativity and a bold shift.

LTC Jerry Glasow presented a paper in our working group that classifies collaborative methods as being either "input-based" or "output-based." MRS-05 typifies the former while the Phased Threat Distribution (PTD) Study is an example of the later. The "input-based" approach reasons that if the participants accredit (1) the data, (2) the tools and (3) the analysts, the results will, in turn, be accredited. When this approach is implemented by a sequence of models (e.g., air defense precedes deployment precedes force-on-force evaluation) a single point failure can delay the entire project. It also tends to produce point estimates rather than a range of possible outcomes for consideration.

Two advantages of the "output-based" approach are parallel, independent analysis and multiple results that can be compared. The most difficult part of this approach can be determining why the results are different. If this approach is used, several integrated teams should be commissioned by the participants rather than putting the participants in competition with one another.

WG #2 Enabling Collaboration

Observations on Data Collection and Production

- Data collection, production and preservation need to be integrated into day-to-day operations:
  - Need to address multi level security issues.
  - Need to capture operational data at JTF level while data is still purple.
  - Need to plan for data capture.
- Collaboration slows as data collection and production burden increases:
  - Deluge of requests during operations.
  - OPSEC issues.
- Must understand limits of data:
  - Close-hold / incomplete data.
  - Data collection, production, preservation are manpower limited.
- Documentation critical to accrediting data for collaborative use
  - Includes metadata (technical, informational, operational).

Data collection, production, preservation and maintenance was a recurring theme in our deliberations. Jim Methered, citing his experience during and after OPERATION ALLIED FORCE, is vehement that data collection must be a component of the JTF information management plan instead of the "ad hocery" that exists today:

"...scavengers picking over small, rapidly decaying, incomplete, and questionable data and then fiercely defending the scraps gathered from others."

A potential major future role for operations analysis may be to study how information is used and develop ways of managing and using it better. Process engineering in peace might facilitate analysis in war as well as improve actual and simulated decision making processes.

WG #2 Enabling Collaboration
Recommendations

- **People**
  - Find ways to identify (and evaluate?) Subject Matter Experts (SMEs).
  - Find a means to develop operational experience in Civil Service 1515s and uniformed analysts w/o warfighting specialties.
- **Process**
  - There is a spectrum of collaborative analysis processes, and each has its strengths and weaknesses (bold shifts versus consensus).
    - » Can organize for competitive analyses.
    - » Can organize to search for a "common ground" solution.
  - Collaborative Analysis is a "teamsport" and requires practice.
    - » OA support to commanders in the field most effective when "train as you fight" has been implemented.
  - Reestablish formal liaison/exchanges to improve the quality of analysis.

MORS
MILITARY OPERATIONS RESEARCH SOCIETY

Our recommendations have been collected under the headings of "People," "Process" and "Product."

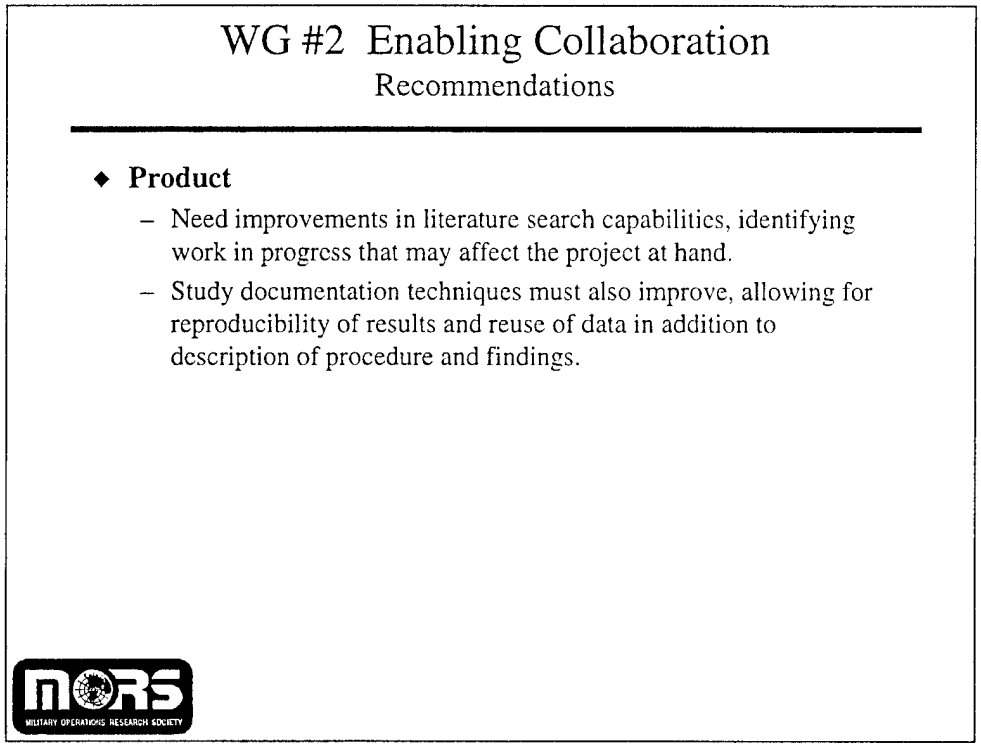
Collaboration requires colleagues with whom to collaborate. We believe there should be a better way of identifying the experts in our community than word of mouth. We also recognize that changes in the way the uniformed services are managing the careers of military analysts may make collaborative work more essential in the future. We must either find a way to increase the "field experience" of our analysts or find ways to include "operators" in our analysis teams.

Collaborative analysis takes longer to perform than analysis done in isolation. Timelines can be shortened if informational exchanges and liaisons between analytic organizations/agencies are institutionalized in our business practice.

WG #2 Enabling Collaboration
Recommendations

- **Process** (Cont'd)
  - Support independent, accredited sources for data to speed collaborative effort.
  - Find ways to identify data to source new applications and phenomena.
  - Data collection must be deliberate and done in such a way that it does not require additional effort by operators.
  - Synchronize data production with data demands and institutionalize production and update of long-lead items.
    - E.g., extend JMEM to include developmental systems.
  - Harmonize schedule of major collaborative projects and Service workload.

In the short-term, its important that we reconcile our demands for data with our ability to produce it. Dr. Chris Lamb, ASD (Strategy and Threat Reduction) is currently leading an effort with the services and the intelligence agencies to better coordinate our efforts. It also makes good sense to plan in advance for the long-lead data that are common to many of the studies we do (e.g., Time-phased Force Deployment Data or TPFDDs) In the long-term, data collection in the operational environment needs to evolve from something that interferes with task performance to something that is transparent to people performing their day-to-day tasks. Similarly, directives to perform large, collaborative analysis needs to be harmonized with the day-to-day analytic workload.



Compressed decision-cycles and the tendency toward using briefings rather than reports as deliverables has lessened our use of literature search and our discipline to thoroughly document what we do.

MORS Workshop

Evolving the Practice of Military Operations Analysis in DoD

Working Group #3
New Analysis Challenges

Chair: Steve Pilnick

Co-Chair: Suzanne Beers

February 29, 2000 through March 2, 2000

Naval Postgraduate School, Monterey, CA

Working Group #3 Members

Dr. Steve Pilnick	NPS	Chair
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Prof Dave Schrady	NPS	
Mr. Joe Stewart	MITRE	
Mr. Chuck Werchado	USN/N81	
LTC Mark Woempner	TRAC	

Working Group #3 Presentations

- Dr. Jackie Henningsen, *Air Force Analysis in the Context of Today's Expeditionary Aerospace Force*
- Capt Russ Bergeman, *Analytic Challenges of the USMC*
- Mr. Chuck Werchado, *OPNAV Naval Analysis: Recent Navy PPBS Process Changes and QDR Analysis Initiatives*
- LTC Jeff Appleget, *Challenges in Army Modeling*
- Mr. Mike McCurdy, *Analysis Challenges for Joint Operations - A USCINCPAC Perspective*

WG #3 New Analysis Challenges
Applicable Workshop Goals and Objectives

- Questions
  - What problems are not well served by the current state of the practice?
- Goals
  - Develop a shared understanding of the need to evolve the practice of Military Operations Analysis in DoD.
  - Establish a vision for improving analytic practice.
  - Objectives.
  - Identify weaknesses in the current practice relative to current and future requirements.

The objective of Working Group #3, New Analytical Challenges, was to address the weaknesses in the current practice of analysis within the Department of Defense.

The working group focused on giving each of the services and the Joint Staff the opportunity of presenting their current analytical challenges...problems that they are facing that cannot be solved with the current analytical toolset. The working group's goal was to define the areas that need to be evolved within the practice of DoD analysis.

WG #3 New Analysis Challenges
Focus Question

- What are military operations analysis questions of interest for which the established military operations analysis community apparently does not have answers?
  - i.e., What problems are not well served by the current state of the practice?

The focus of Working Group #3 was to examine military operations analysis questions of interest for which the established military operations analysis community apparently does not have the answers. This working group is about new problems, problems not involving conventional warfare, and/or post-Cold War problems. Actually there are old problems that belong here as well. The issue isn't whether the problem is new or old, but rather whether the Military OR community has succeeded in addressing it satisfactorily. An example is the problem of determining the value of a common operational picture to the warfighter. Presentations to this working group came from the major analysis players such as the Services' Studies and Analysis shops, from warfighters like the Joint Forces Command and USCINCPAC, and from decision makers like OSD, J8, and the Services' warfare requirements and assessment organizations.

WG #3 New Analysis Challenges

Problems not well served by the current state of MOR practice

- Methods for Analyzing New Domains of Operation
  - High intensity/low casualty conflict
  - MOOTW, humanitarian operations, peacetime engagement, operations in urban terrain
  - Technology insertion (digital battlefield, tomorrow's dismounted warrior)
  - Chemical/biological warfare effects (including contagion)
  - Asymmetric threats (terrorism, political manipulation, homeland defense)
    - » Means for recognizing attack
  - Application and effects of special operations
  - Information operations/warfare

With the end of the Cold War, the Department of Defense and thus the DoD analytical community, are faced with the demand of conducting and analyzing a variety of new operations. These new operations require new methods of analysis for planning, conceiving concepts of operations, defining doctrine and analyzing effectiveness. Some examples of these new domains are: High Intensity/Low Casualty Conflict, Military Operations Other Than War (MOOTW), humanitarian operations, peacetime engagement, operations in urban terrain technology insertion (digital battlefield, tomorrow's dismounted warrior), chemical/biological warfare (including contagion), asymmetric threats (domestic terrorism, political manipulation, homeland defense), special operations and information operations/warfare.

WG #3 New Analysis Challenges

Problems not well served by the current state of MOR practice

- Model-centric focus limiting analysis toolkit
  - Scenario development and data collection time consuming
  - More scoping analysis to set stage for detailed study
  - Encourage exchange of simple analysis tools (e.g., spreadsheets)
  - Combine results from all pertinent tools
- Identifying complex interrelationships between factors
  - communicate effects of multi-dimensional trade space

The current emphasis on modeling and simulation with it's resulting de-emphasis on other analytical tools and methods is limiting the analysis toolkit. With the amount of time and resources required for scenario development and data collection to run the current models and simulations, some other alternatives are clearly needed. For example, methods of scoping analysis that can quickly look at the alternatives and potentially set the stage for further, larger, study are needed. These scoping tools can serve to pare down the alternatives and allow the focus on the important question to evolve. In addition, simpler analysis tools such as spreadsheets should be used and exchanged within the analytical community as a rapid means of knowledge transfer. Finally the analyst should be taught to combine the results from all pertinent tools and analytical methods to more thoroughly, accurately and quickly answer the question at hand.

With the increasing complexity of today's military scenarios and high technology weapons, there is a greater need for the analysis community to be able to identify and communicate the effects of the factors and their interrelationships. It is especially important to be able to conduct and communicate the trades conducted between factors that typically would not be linked. For example, an aircraft carrier can be the platform used for JSF launches, and a typical analysis may look at the number of targets put at risk by various sizes of JSF fleets. However, an interrelated measure that should be considered is the deck space that is being taken up by the JSF fleet, that may potentially be used for such things as helicopter medevac support...two very important missions with interrelations that must be considered.

WG #3 New Analysis Challenges

Problems not well served by the current state of MOR practice

- Analytical methods that trace factors to operational and strategic outcomes:
  - Logistics
  - Bandwidth
  - Engagement/presence on PERSTEMPO and OPTEMPO
  - Infrastructure Investments
  - Readiness postures
  - Force structure changes (deployable, lighter, lethal fighting force)

There are many factors that effect the outcome of a battle, but do not have directly measurable combat effects. These factors must be taken into account, and their effects must be traced to operational and strategic outcomes. These factors include such things as logistics, bandwidth requirements, engagement/presence on PERSTEMPO and OPTEMPO, infrastructure investments, readiness postures and various force structure alternatives.

WG #3 New Analysis Challenges

Problems not well served by the current state of MOR practice

- Methods for including behavior factors in current tools
  - Quantifying small unit behavior
    - » Effect of situational awareness on force effectiveness
  - Quantifying adversary leadership motivation
    - » Effect of target selection in influencing course of action
- Methods of quantifying risk
- Real time analysis for operational support

The behavior of individuals, small units, and adversary leaders must be captured in our evolving analytical tools. The effect and measurement of behavior factors at the individual or small unit levels are important considerations, especially in the analysis and evaluation of combat systems. For example, the increase in situational awareness for the individual foot soldier is probably a good thing, to a point — until information overload occurs or if the equipment used to give the situational awareness decreases the individual's effectiveness in other areas, such as mobility. On the other hand, being able to quantify the characteristics and motivations of an adversary leader would allow the identification of the leader's or country's centers of gravity and may assist the planning process in identifying effective target sets that would influence the enemy's course of action.

Methods for quantifying risks of all sorts must be developed and institutionalized.

The frequency of calls for quick-turn around analysis is increasing. These analyses take many forms, such as support for testimony to Congress or support to ongoing warfighting efforts. To answer these types of questions, the analyst needs a set of tools that support these quick analysis activities. These tools need to capture the important elements that would be drawn out by more thorough analysis but run quickly enough to support answering the question when the answer will still be desired and relevant.

WG #3 New Analysis Challenges
Recommendations

- Find methods to deal with:
  - New forms of operations.
  - Traceability of known factors and interactions.
  - Quick turn-around studies.
- Nurture analysts and analytical thinking rather than focusing on model development:
  - Project more balanced view of model capabilities and limitations.
  - Reverse trend to big models as solution to all problems.
- Characterize and communicate impact of uncertainties (e.G., Risk, behavioral factors).

In summary, as the analytical community evolves it needs to find tools to deal with new forms of operations, find methods to trace known factors and interactions to their logical combat output, and find tools that will provide accurate and thorough analysis in a short timeline.

The DoD analytical community needs to nurture analysts and emphasize analytical thinking rather than focusing on simulation and modeling development. The community must project a more balanced view of model capabilities as well as limitations, and reverse the recent trend of blind faith toward large models as the solution to all analytical problems.

The analytical community needs to find means for characterizing and communicating the impacts of uncertainty. For example risk, such as decision risk based on the fact that various factors may not have been considered in the current analysis, need to be characterized and communicated to the decision maker.

Backup Slides — Session Notes

The following slides provide the notes taken during the presentations and the resulting discussions of the working group sessions. The problems identified in the previous slides were distilled from these session notes.

WG #3 New Analysis Challenges

Session Summary

- Methods for recognizing/analyzing unrestricted warfare
  - New domains of warfare, warfare reborn
  - Terrorism, high intensity/low casualty conflict
- Apply traditional OR methodologies, but consider methods for including behavior factors
  - Draw upon expertise of multi-disciplinary teams (behavioral scientists, psychologists, etc.)
  - Effect of target selection to force enemy capitulation
- Need measures to relate warfare outcome of non-warfare factors and metrics for other operations
  - Logistics, bandwidth
  - MOOTW, humanitarian operations

During her keynote address, Dr. Ruth Davis introduced the concept of unrestricted warfare. With this concept, war has been reborn, focused on such activities as terrorism and high intensity/low casualty conflict. These types of warfare emphasize the need to analyze economic and police efforts, something that the current analytical community tools are ill prepared to handle.

We need to recognize that the behavioral science fields, although not as measurable as other tools, provide useful information to policy decision makers. Part of OR analysis' value to decision makers may be to use these sciences to identify alternatives or structure the decisions. For example, developing a model that relates an adversary leaders' motivations and vulnerabilities, could potentially be used to identify the target set that would force that leader into capitulation.

The use of measures that quantify warfare outcomes, such as attrition, are well known. However, there are many factors that support warfare operations that are not directly quantifiable with the current measures and analytical techniques. The community needs to identify metrics that can be used to quantify the value of these non-warfare factors, such as logistics and bandwidth use and other types of operations, such as MOOTW and humanitarian operations.

WG #3 New Analysis Challenges

Session Summary

- Communicate effects of multi-dimensional trade space:
  - Different system solution options, multi service.
- With changing CONOPS and doctrine, analysis methods and human factors assessments must catch up:
  - Information technology insertion (digital battlefield, tomorrow's dismounted warrior).
  - Force structure changes (deployable, lighter, lethal fighting force).
  - Operation in urban terrain.

The analytical community needs to find new techniques that will allow the capability to communicate the effect of the factors within a multi-dimensional trade space. This trade space includes trading various system solutions or options offered across service boundaries.

The new environment that includes rapidly advancing technology and the paradigm that "change is good" is rapidly changing CONcepts of OPerationS (CONOPS) and doctrine. While the way the military does business is rapidly changing, the environment is also providing new analytical challenges. We need to figure out how we fit into this new environment, and develop tools that will answer questions such as:

- How to assess the benefits and drawbacks of information technology insertion, such as the digital battlefield and tomorrow's dismounted warrior. For example, is there a point where too much information is too much for the warrior?

- How to assess the benefits and implications of proposed force structure changes.

- How to model operations in urban terrain, such as determining the level of detail of modeling buildings in an urban environment.

WG #3 New Analysis Challenges

Session Summary

- Challenges from analytical support to CINC's
  - Analysis tools and data for OOTW and peacetime engagement
  - Indicators of inter/intra-state instability
  - Real-time analytical support for operations and exercises
    - » Short analysis time frame
  - Field analysis of operations and exercises
  - Combining training and analysis
    - » Simulation support for mega-CAX's
    - » Combining analysis and exercise results

From the CINC's viewpoint, there are a variety of analysis challenges.

Real time analytical support for operations offers a different environment, due to the very short timeframe allowed for the analytical activities. There is no time to build data bases, therefore the most valuable resource that the analyst can offer is an operational focus and a structure for thinking about the problem.

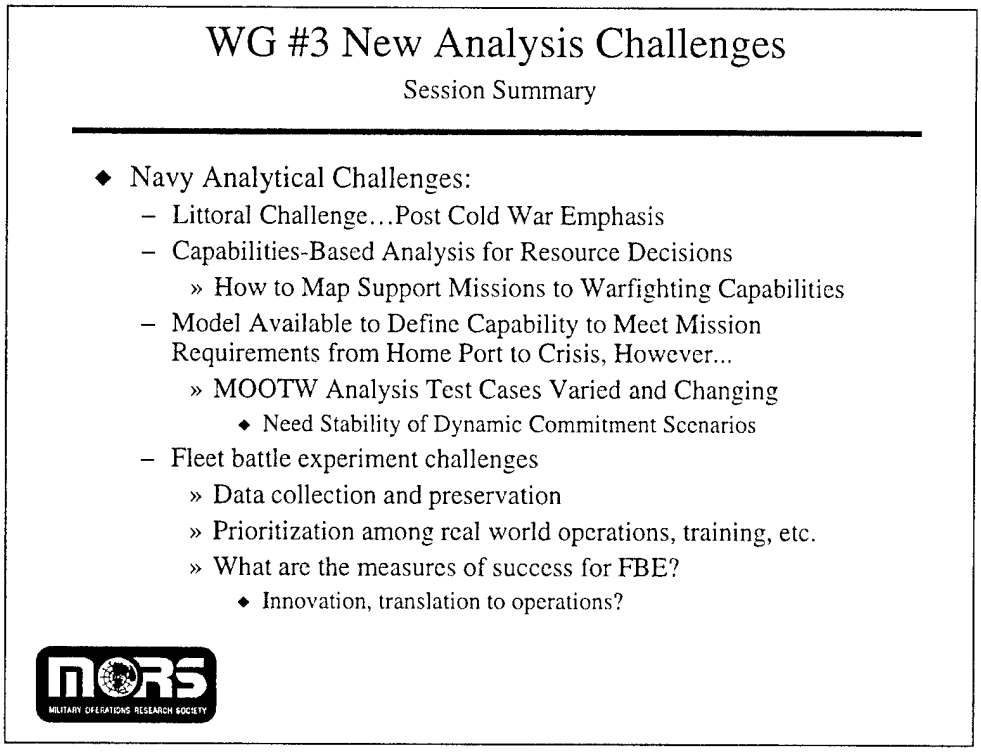
Training simulations provide challenges in a few areas. Increasing the simulation support for combining many of the large exercises, and combining analysis and exercise results.

WG #3 New Analysis Challenges

Session Summary

- QDR analysis challenges:
  - Methods of quantifying risk and uncertainty.
  - Feedback loops to include analysis in planning.
  - Analytical transparency.
  - Effects quantification:
    - » Engagement/presence on PERSTEMPO and OPSTEMPO.
    - » Infrastructure Investments.
    - » Readiness Postures.
    - » Chemical/Biological Warfare Effects.
    - » Asymmetric Threats (terrorism, political manipulation).
    - » Information Operations/Warfare.
  - Compares Four Alternative Force Structure Emphases against Four Scenarios.

These analysis challenges were extracted from Tom Allen's QDR Workshop presentation during Wednesday's plenary session.

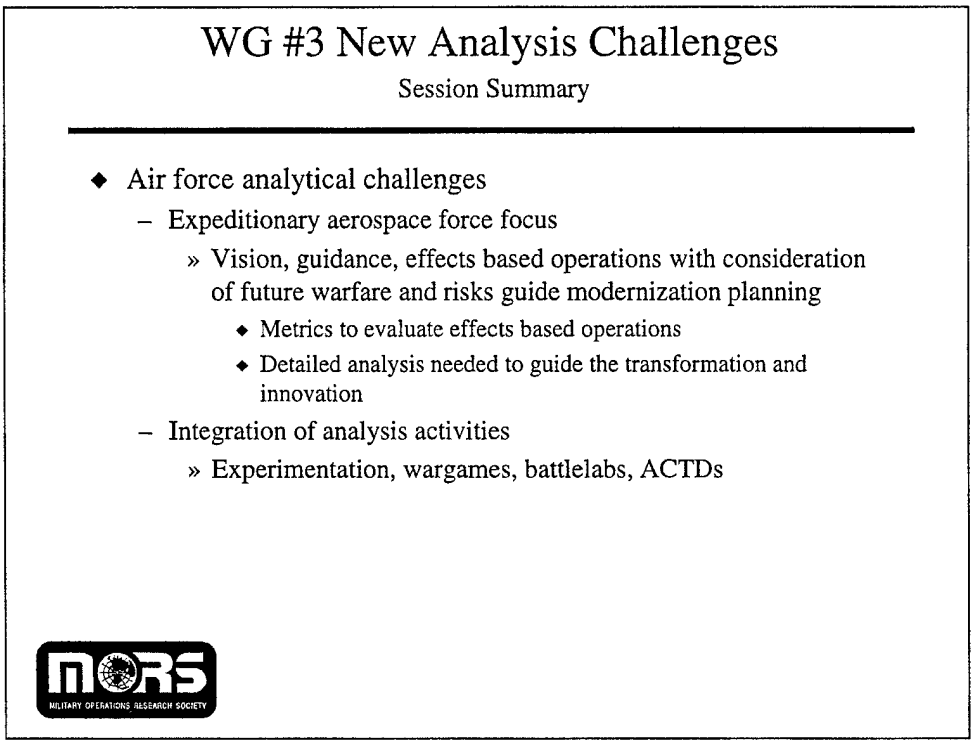


Without the existence of a comparable Navy opponent for battles on the high-seas, the Navy will be faced with a "new" form of warfare...fights in the littorals. This new form of warfare will require new analytical tools to help define the appropriate force structures, doctrine, and tactics required to fight these crises.

The IWAR/CPAM system is an end-to-end capabilities analysis method used to make resource decisions. The analytical challenge provided by this is to define the linkage between the support missions to their contribution to warfighting capabilities.

The IWAR/CPAM process uses a model (FORSAT) that defines the capability to meet mission requirements from home port to the crisis area. The issue provided with this tool is the definition of the MOOTW scenarios. The scenarios are varied, changing, and growing by the day. The analysts, with current funding levels, cannot keep up with the development of the scenarios needed to describe the MOOTW conditions.

The Fleet Battle Experimentation (FBE) program provides the Navy a means for evaluating new operational concepts within the fleet environment. Analytical challenges presented by the FBE is data collection and preservation, and thus translation into doctrine and operations. Due to the conduct of FBE within the active fleet, it necessarily takes a back seat to real world operations and other priorities during fleet operations.



A previous CSAF decided that analysis did not fit well with his vision of the Air Force. He made the decision to decrease the size and organizational standing of the Air Force Studies and Analysis Agency (AFSAA). This decline has had many negative aspects, including the separation of blue suit analyst from contractor supported analysis. In many cases, the linkage between the analysis and decision making has been lost. At the same time that the analysis capability has been drawn down and de-emphasized, there has been an increase in analysis "911" calls from various sources such as CSAF, Congress, AF/XP, etc.

The Expeditionary Aerospace Force concept offers many challenges. The combination of vision, guidance, and the consideration of effects based operations combine to guide modernization planning. During this planning process, future warfare and the decision risks involved must be considered. These radical changes in the AF doctrine and operations must be guided by thorough analysis activities that will guide the transformation and innovation.

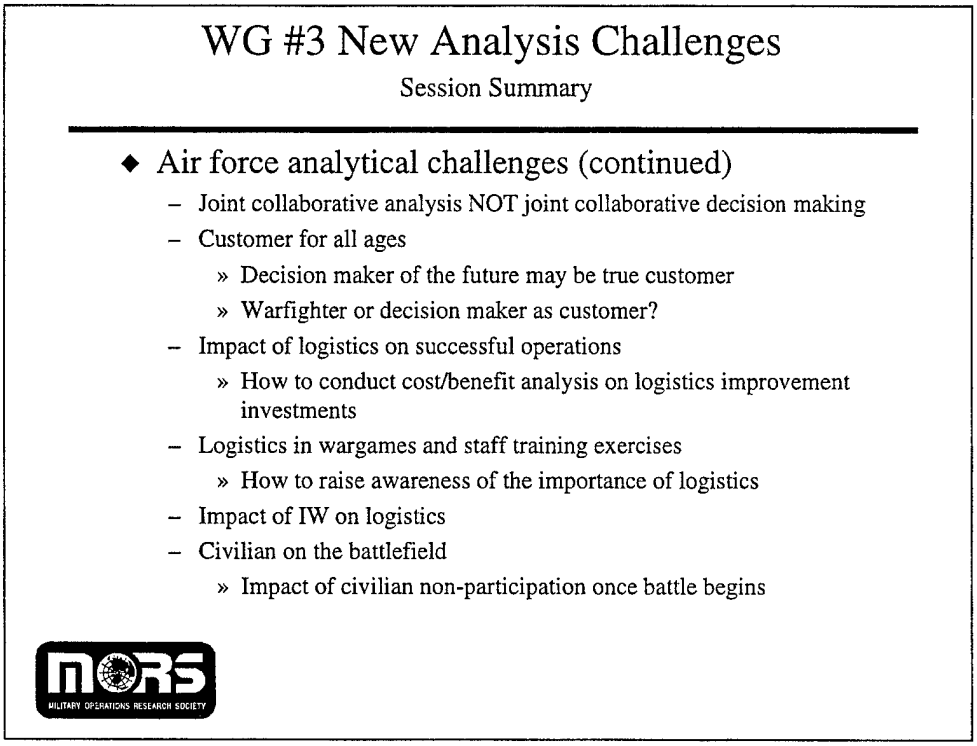
The need to systematically link all analysis activities is desperately needed to include the information and knowledge gained from the various activities, such as experimentation, wargaming, battlelab initiatives and ACTD's /ATD's

WG #3 New Analysis Challenges

Session Summary

- Air Force analytical challenges (continued):
  - Model-centric focus limiting analysis toolkit
    - » Scenario development and data collect time consuming.
    - » Need "scoping models" to quickly assess alternatives.
  - Global vs. local optimization
    - » OR community has the training to understand both.
    - » Need tools to combine local (service specific) suggestions into global (Joint) solution.
  - Technology balance
    - » Need to be careful of chasing technology at the expense of intellect.

The current emphasis on M&S as the primary analysis tool, limits the capability of the analyst. Scenario development and data collection required for high-resolution models are extremely time-consuming tasks and thus limit the analyst's ability to support quick-turnaround or small analysis questions. A gap-filler or "scoping model" is required to quickly assess alternatives that may subsequently be studied further with the high resolution or campaign models.



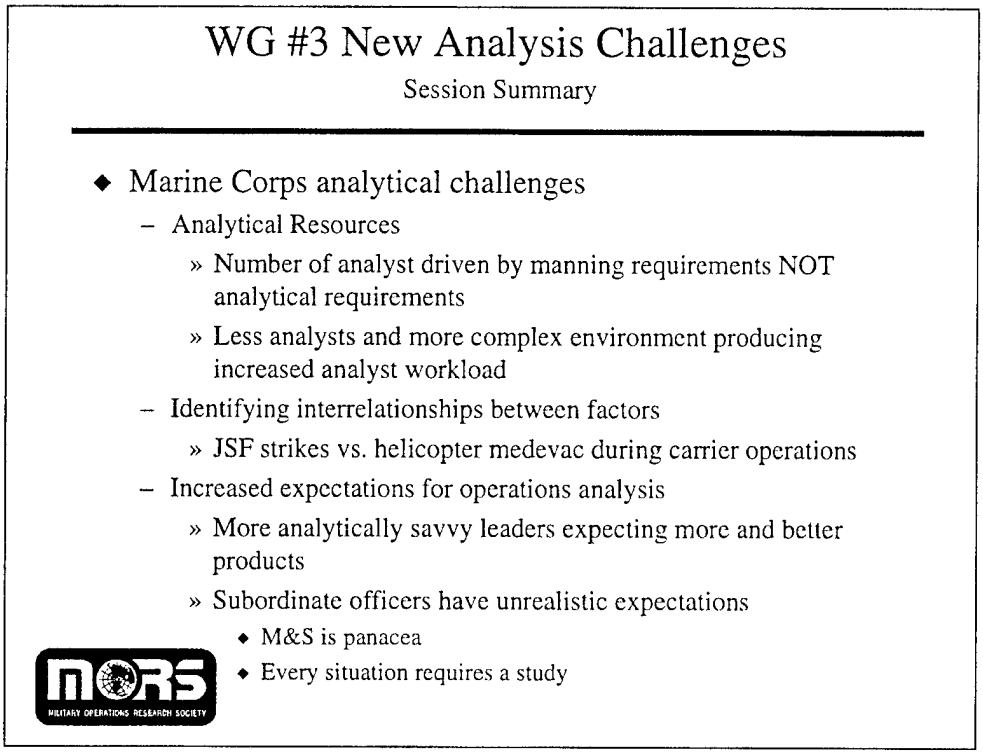
The customer for our analysis capabilities may very well be the decision maker of the future, rather than current decision makers. Given this focus, how do you structure the analytical community's activities to meet the needs of this customer.

The impact of logistics on the battlefield has not been adequately modeled in the current modeling tools. For example, modeling the impact of logistics on successful operations requires the need to do things such as cost/benefit analyses on logistics improvement investments, and quantifying the costs and benefits with respect to combat operations.

In order to raise the awareness of the importance of logistics in senior leadership and planning efforts, there is a need to include logistics considerations in wargames and staff training exercises. Rather than allowing the decision maker to assume away all the logistics activities, they must be included in their thinking processes.

What is the impact of information warfare on the conduct of logistics and thus the conduct of combat operations? For example what is the impact on combat operations when the logistics system supported them is attacked and brought down by information warfare operations?

The impact of civilian participation on the battlefield needs to be considered and what the impact of their loss will be. For example, when the shooting began during Operation Desert Storm the UPS pilots providing logistical support refused to participate.

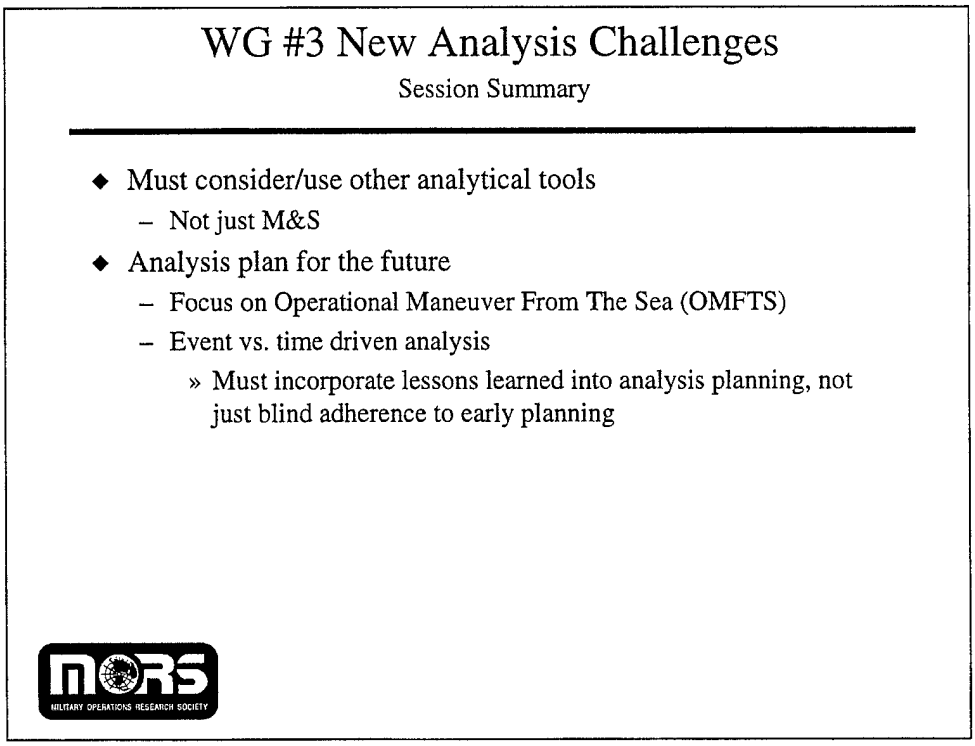


The USMC is facing several analytical challenges: conflict of analytical resources and requirements, increased expectations of analysis; both leading to the need for a comprehensive analysis for the future.

The number of USMC analysts is driven by manning requirements, not by the number of analytical requirements that the USMC is facing. This combination of more complex analytical problems and a small number of analyst combine to create a greater workload for each USMC analyst.

The inability to define and analyze the interrelationships between systems, missions and functions provides an analytical challenge. For example, increases in JSF sortie generation rate allows the USMC to strike more targets ashore, but at the same time consumes deck space that may have been used for helicopters that could evacuate wounded from the ship. How are diverse, yet interrelated factors traded off in a comprehensive analysis?

Increased expectations of the analytical community are spawned from savvy senior leaders who are demanding more and better analytical products. On the other hand, not so savvy mid-level leaders introduce unrealistic expectations for the community. They bring expectations that M&S is a panacea and that every question needs an analysis.



The analytical community MUST consider other tools rather than just focusing on M&S to answer every question.

Analysis plan for the future focuses on Operational Maneuver From the Sea (OMFTS). Lessons learned must be incorporated in the planning and execution of future analytical activities.

MORS Workshop

Evolving the Practice of Military Operations Analysis in DoD

Working Group #4
New Analysis Tools and Methods

Chair: LTC Dan Maxwell
Co-Chairs: John Furman and Dr. Al Brandstein

February 29, 2000 through March 2, 2000
Naval Postgraduate School, Monterey, CA

The Charter of the New Analysis Tools Working Group was to identify emerging tools and techniques for conducting operations analysis, given the new challenges that face the military operations research community in the 21st century.

To accomplish this, MORS leadership assembled representatives from domains that are not normally part of the traditional MORS population. Experts with expertise in C4I systems, intelligence, policy analysis, artificial intelligence and knowledge management were present. This eclectic set of skills resulted in information exchange that exceeded expectations — a vision focused on providing a foundation of consistent and compatible data, as well as an architecture that could provide connectivity between command and control systems and analytic modeling environments.

The kinds of connectivity and consistency that are envisioned in this product are believed to be absolutely essential for providing commanders and staffs in the field with flexible automated planning support, and keeping analysis relevant in the highly uncertain future that the DoD faces.

Perhaps most importantly, it was concluded that for the most part there is no technological impediment to achieving the vision that is articulated herein, and that these kinds of efforts are an essential part of achieving the knowledge management "culture" that has been implemented successfully in many commercial enterprises.

Working Group #4 Members

LTC Dan Maxwell	ODPA&E/JWARS	Chair
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Capt Russ Bergeman	MCCDC	
LtCol Eileen Bjorkman	ICAF	
Mr. Curt Blais	NPS	
Mr. Gary Brisbois	MITRE	
Mr. James Calpin	MITRE	
Mr. Brad Canova	MITRE	
MAJ Curt Doescher	AMSO	
Mr. Francis Dougherty	IMC	
LtCol Norm Edwards	J-8/SAMD	
Mr. Don Fithian	Joint Interagency Task Force East	
Mr. John Furman	MITRE	

Working Group #4 Members (Cont.)

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Dr. Patricia Jacobs	NPS
Dr. Jimmie McEver	RAND
Mr. George Phillips	CNO/N812
Mr. Jeff Rogers	NOESIS
MAJ Sue Romans	CAA
DR Kevin Saeger	ODPA&E
Dr. Gordon Schacher	NPS
Dr. Bob Sheldon	S3I Inc.
Prof Alan Washburn	NPS
Mr. J P Wilusz	GRCI Inc.
LTC Willis Woods	DISC4/SADC
Dr. Mark Youngren	MITRE

Working Group #4 Presentations

- MAJ Curt Doescher, *Modeling and Simulation Standards Development*
- Dr. David Horner, *A Standards-Based Methodology for Throughput for Use in Movement Representation in Modeling and Simulation*
- Ms. Kay Burnett, *Conceptual Modeling of Foreign Command Decision Processes*
- Dr. Mike Hieb, *Data Alignment - C4I and M&S*
- Ms. Elaine Simmons, *Employing Data Warehousing Technologies in Support of Analysis*
- CPT John McKitrick, *Army Flow Model*

WG #4 New Analysis Tools and Methods Focus Questions

- What currently emerging developments in analytical approaches to complex systems can be applied to challenging military operations analysis problems?
  - Consider areas such as chaos, complexity theory, etc.
- To what DoD analyses, particularly the new analytic challenges defined by WG3, can these approaches be applied?
- What recommendations do you have to improve the existing analytic practice in the near term by using new analysis tools and methods?
- What recommendations do you have for areas of research for the next generation military operations analysis?

The MORS leadership asked the working group to identify developments in analytical approaches to complex systems that were emerging. While some of the areas were explored in the course of discussion, it is clear that there was much relevant research that was not able to be addressed in the compressed time schedule of a three day workshop.

We attempted to map our discussion to the products of working group three. However, this topic is better addressed by the report of the synthesis group.

The group did deliberate and prepare a set of recommendations on actions that could be taken by the DoD to improve the analytic practice, as well as improve the coordination with other domains of expertise.

Objective

- To identify emerging techniques and tools that will support military operations research.
- To map these concepts to the Department's analytic challenges
- To develop a set of near term investment recommendations for the MORS Sponsors' consideration
- To develop a set of longer-term research and development recommendations for the MORS Sponsors' consideration

Our objectives were derived directly from the focus questions that were presented to the group by the MORS leadership.

One of the challenges for this working group was to identify real needs for improvements in tool and/or data capabilities given knowledge management's emphasis on better exploiting existing technical capabilities. We searched for existing capabilities to exploit and attempted to organize our recommendations based on the vision you will see in a later slide.

Assumptions and Scope of Exploration

- Knowledge management technologies will provide a "repository" in which these tools and techniques will be made available to analysts. (Limit WG scope to models, data and data development.)
- Earlier objectives in the modeling and simulation master plan regarding reuse in modeling, simulation and analysis still hold.
- The hardware and software infrastructure will support interoperability of systems (e.g. HLA and DIICOE).
- Un-addressed deficiencies identified in the analysis functional working group report remain valid.

Because the solution space was potentially vast and unmanageable in a workshop setting, the group made initial assumptions to bound the discussion. In some cases the assumptions were found to be to restrictive and were necessarily relaxed.

The first assumption is that KM experts will create a repository infrastructure, and that infrastructure will be available for use to store and distribute analysis domain knowledge.

Analysts and the DoD have been modeling and simulating for a long time. There is an existing set of recommendations in the DoD Modeling and Simulation Master Plan. These recommendations are assumed to be good, and future recommendations should deviate only when needed.

There are known architectures available to us to move information between analytical models that could facilitate a knowledge management oriented system and culture. One example is the High Level Architecture (HLA). There are also known architectures to move information between near Real-Time C4I systems such as the Defense Information Infrastructure Common Operating Environment. While it is logical to assume that these architectures will ensure interoperability, discussion with experts from the C4I domain revealed that the assumption does not currently hold with respect interoperability between analytical models and C4I Systems (i.e., the HLA and the DII COE).

The Analysis Functional Working Group has a valid list of analysis deficiencies that needs to also be considered. We anchored on how to do big studies better then started to look at minute-long decision cycles (from the analysis working group) to balance-out this discussion.

Assertions

- Although warfare doctrine and military missions are evolving, there are constant/recurring analytic requirements that can and should be planned for:
  - Force assessment
  - Planning and execution
    - » Deliberate planning
    - » Crisis action planning
  - System effectiveness and trade-off analysis
  - Concept and doctrine development and assessment

These missions are fairly constant in the workspace of military operations research. There is ever reason to believe they will continue to be the main missions of the future. They form the space around which to structure the new tools for analysis challenges.

Because the group began deliberation at the same time WG 3 was meeting, a generic set of decisions (that could be supported) by analysis were used to stimulate discussion. Over the course of the workshop, the group considered WG 3 inputs as they arrived.

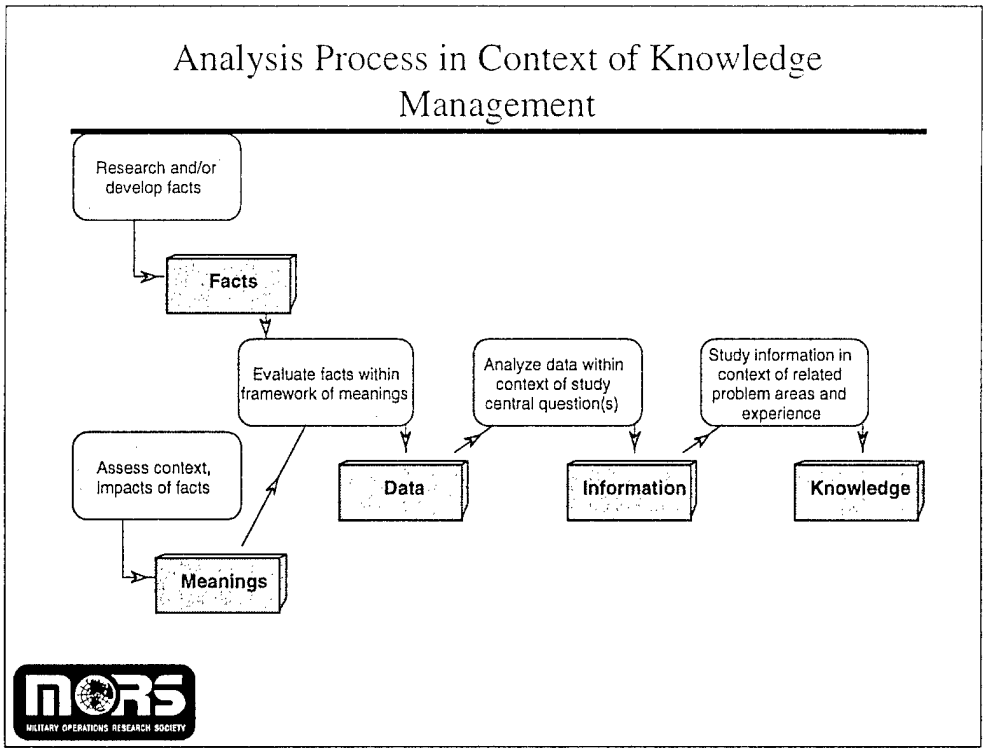
One notable possibility that was added by the C4I domain was the existence of decision aids that are either currently embedded, or planned for in near real-time command and control systems. These systems would benefit from analytically sound underlying algorithms and the group felt strongly that the analysis community will need to be an active part of their development.

Assertions (Cont.)

- Accomplishing these analytic missions require:
  - Descriptive tools (models and simulations)
  - Prescriptive tools (choice and resource allocation)
  - Reliable and consistent data
- A significant body of work is underway in the DoD that advances the state-of-the-art in modeling "infrastructure."
  - Corrects deficiencies inside mission areas
  - Fails to capitalize on related work (schedule and resource constraints)
  - This results in inefficient and inconsistent modeling and analysis efforts.

The taxonomy of models we see here include descriptive representations of the military world and also prescriptive models — those that prescribe a solution to the budget and capability trade space. We need efforts in both arenas to produce the analysis capability to serve the profession in the future.

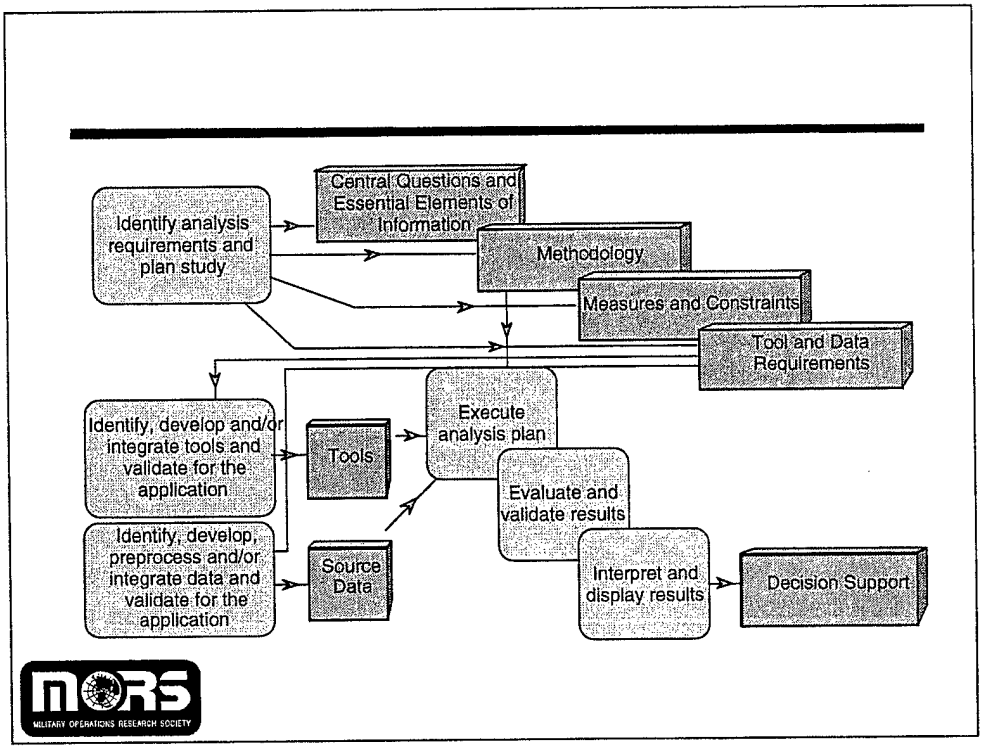
It was further asserted during the opening session that accomplishing these missions must be accomplished within shorter and shorter timelines.



During the conference, we saw this knowledge management framework (the blue boxes) as a hierarchy of knowledge products built on the base of known facts and derived meanings. One of the insights from our work this week is that the application of knowledge management within the analysis community is really a process of becoming conscious of the importance of building and sharing the knowledge of our analysis enterprise — both subject area and analysis expertise.

Knowledge products are produced by the analysis process (shown in yellow). The essence of analysis has always been to create knowledge from the raw materials of facts and meanings.

One aspect of wisdom — the highest level knowledge product shown in the original framework (and missing from the far right side of this diagram) — results from continuing to develop and use analysis capabilities over time.

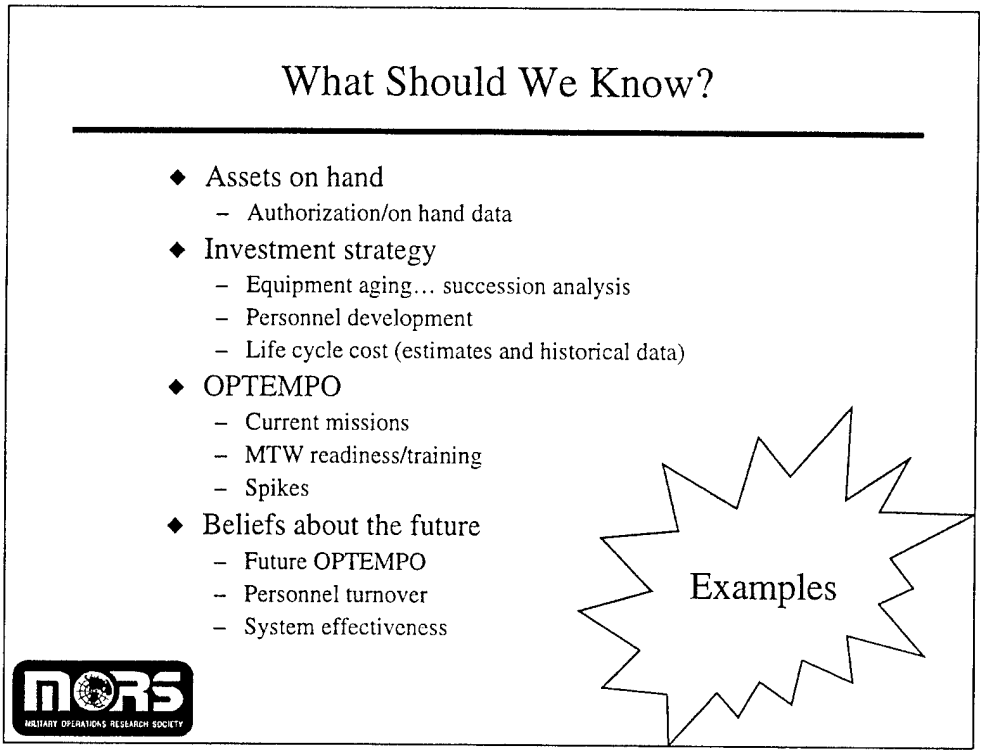


This is a slightly different view of the analysis process and products from the previous slide. It highlights the product areas that the tools working group might consider as areas for improvements.

Much of our discussion centered on tools and data, particularly the need to integrate information generated from multiple tools, sequence data flows from one tool to another, and to ensure that the data objects were consistent such that they could be used as is or logically transformed to meet modeling requirements. The term "model," defined in the broadest sense as the abstract representation of any problem, was frequently discussed as a key tool.

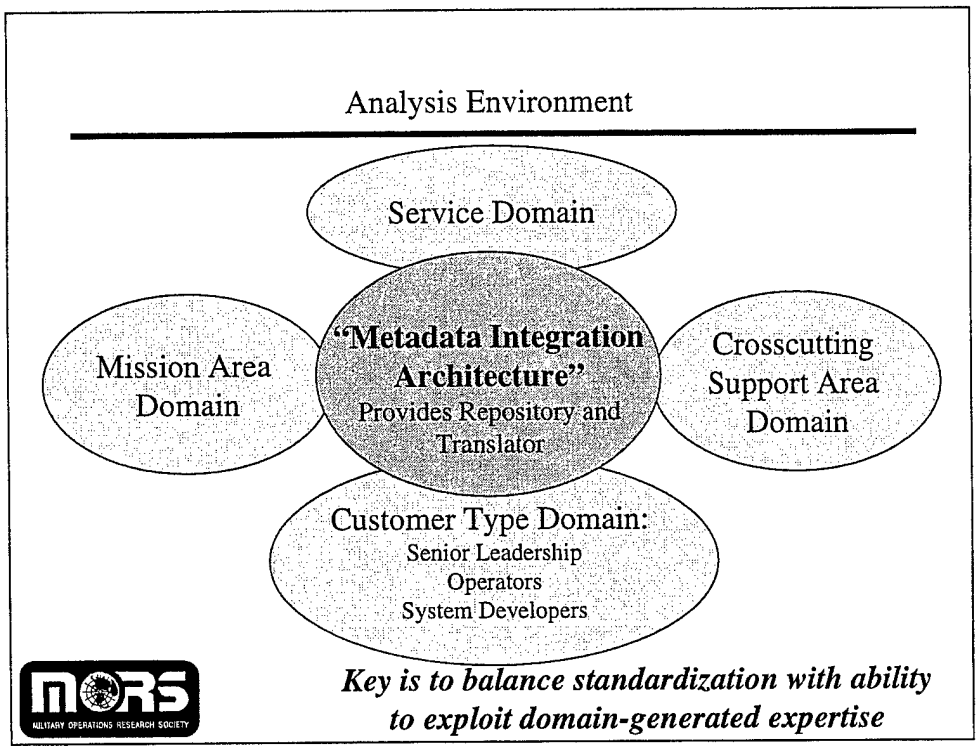
Another emphasis area was to reduce the data-to-tool-to-information cycle time sufficiently to meet the needs of the customers with very short decision timelines. Traditionally, these customers have relied on back-of-the envelope estimates — aka "quick and dirty" analyses — to offer insights to support their decisions. Since these decisions are frequently high-level and wide reaching, the analysis community would like to design tool and data solutions that offer both a high quality and timely response.

Decision support needs centered on visualization tools — the ability to clearly represent complex decision spaces, dissimilar tradeoffs, and the like — that have not yet been identified. The group identified KM practice as their preferred solution option to identify and reuse methodologies and measures.



One of Vince Roske's main points in his introductory remarks was that we "don't know what we know." OR has in recent years concentrated on the mechanical and physical aspects of predictive modeling. This has taken us away from the original roots of the science, which was grounded in the observation of combat processes and their improvement through study.

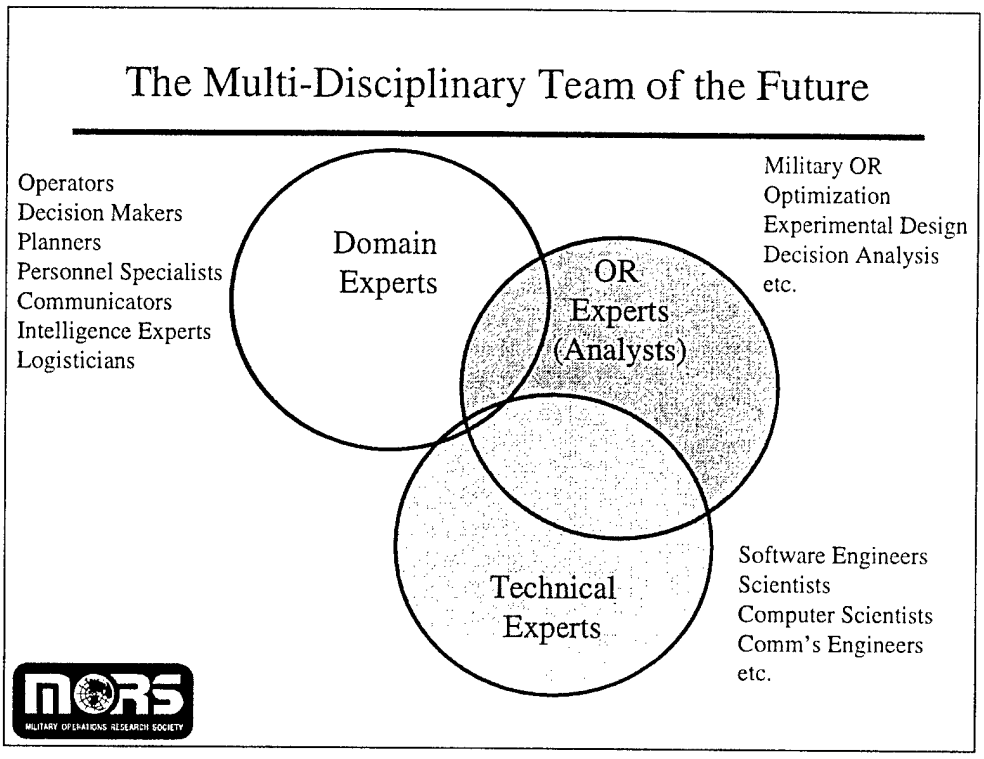
We need to return to these roots and use KM to acquire the information we do know, and catalog it. Exercises, OPTEMPO, and force structure data must be treated as important information that is archived and made accessible to all analysts.



Analysts are called to serve a variety of customer, service, mission and supporting function domains. This slide shows a representative set of domains — there are others. The point is that each domain requires specific analysis perspectives and domain expertise. Analysis capabilities are developed within these domains to meet customer needs. KM offers a methodology and mindset to share information across domains that is represented here as the center "Metadata Integration Architecture."

"Metadata" are data that explain and establish the context for data within a conceptual system. One foundation of the analysis process is to generalize or abstract a problem to a level where it can be addressed with available time and resources and at a level that is consistent with a customer's information needs. The elements of these abstractions can be considered metadata and have the potential to be reused as is or provide a good starting point for future assessments.

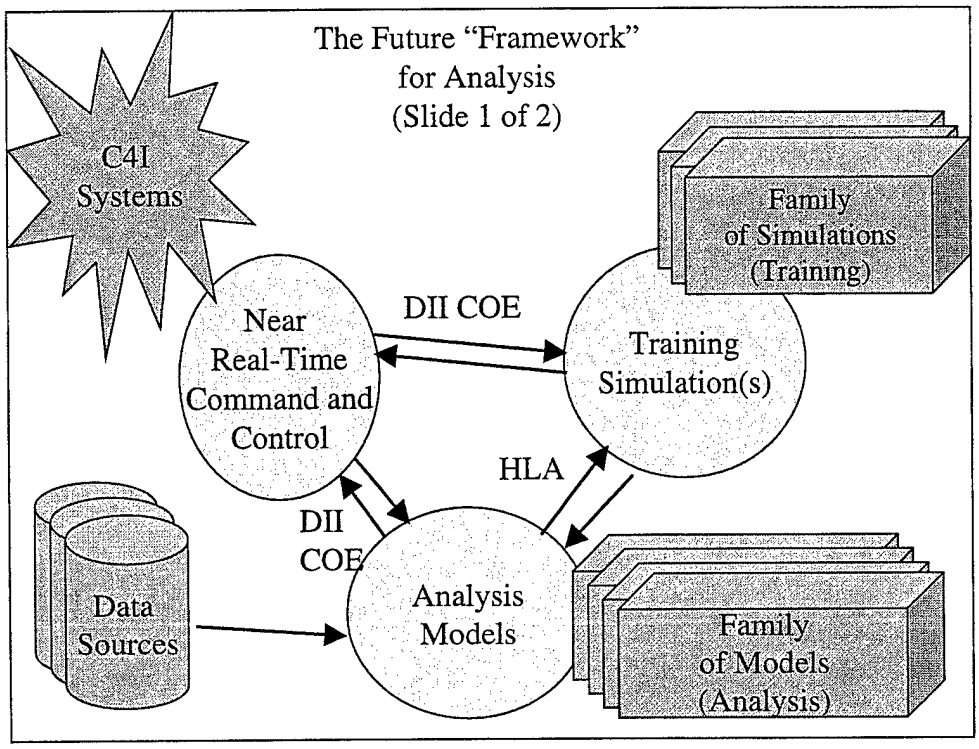
The point is to exploit our body of knowledge to increase the responsiveness and quality of analyses by making best practices easily accessible. The term "standardization" is used as a shorthand for "data objects, algorithms, methodologies, measures and other analysis elements that are acknowledged best practices." The balance is a delicate one — need for communication across domains with need for flexibility to respond to customer needs.



Early OR practice flourished because analysts were able to assemble multi-disciplinary teams, and to bring structure to the problem solving process. Over time OR evolved into a discipline of its own, and reached out to other disciplines as needs were perceived.

The challenges of the 21st century will require advanced, very complex technologies in all domains. This implies that no one person, or discipline, will possess the expertise to assemble a robust system, or even adequately describe a complex problem.

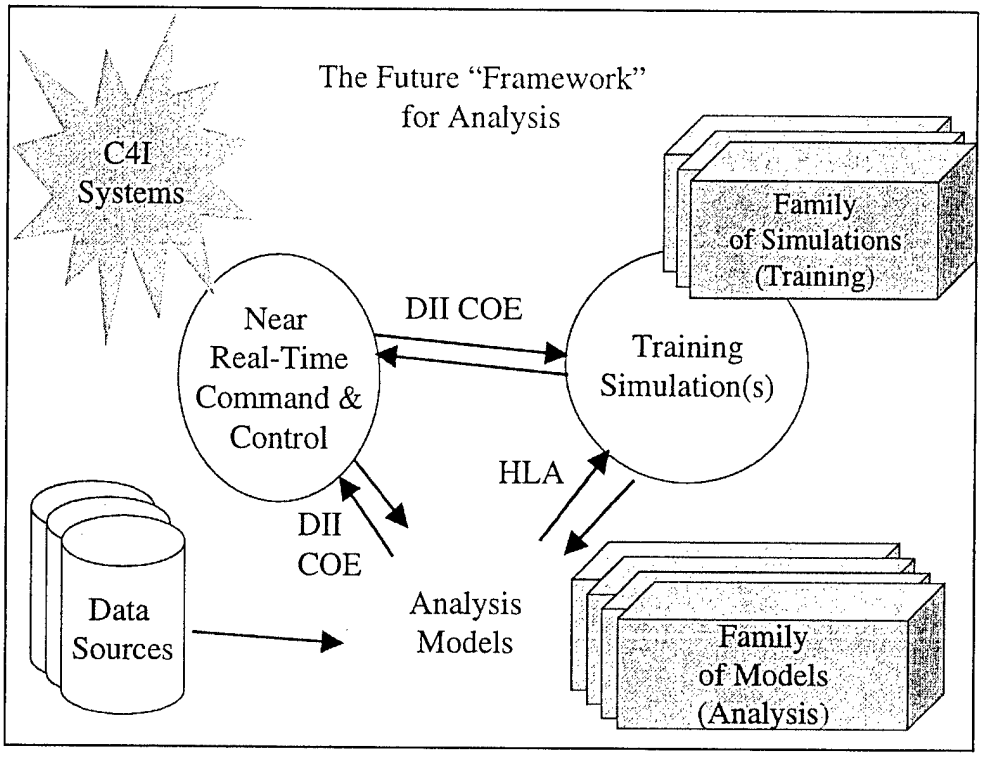
An example of successful collaboration of this type is taking place in the JWARS development project. Descriptions of the JWARS software development process and project are available at http://www.dtic.mil/jwars.



The group developed an "architecture" of systems, software and models that was perceived to be necessary to meet the needs of military leaders, and defense managers in the twenty first century. The kinds of unprecedented connectivity and consistency that are envisioned are required to keep analysis and analysis products relevant inside the short decision cycles that are emerging. It is also necessary to achieve a culture of "knowledge management" in which the system of systems we are attempting to analyze has achieved a complexity that is beyond the comprehension of any one person or discipline.

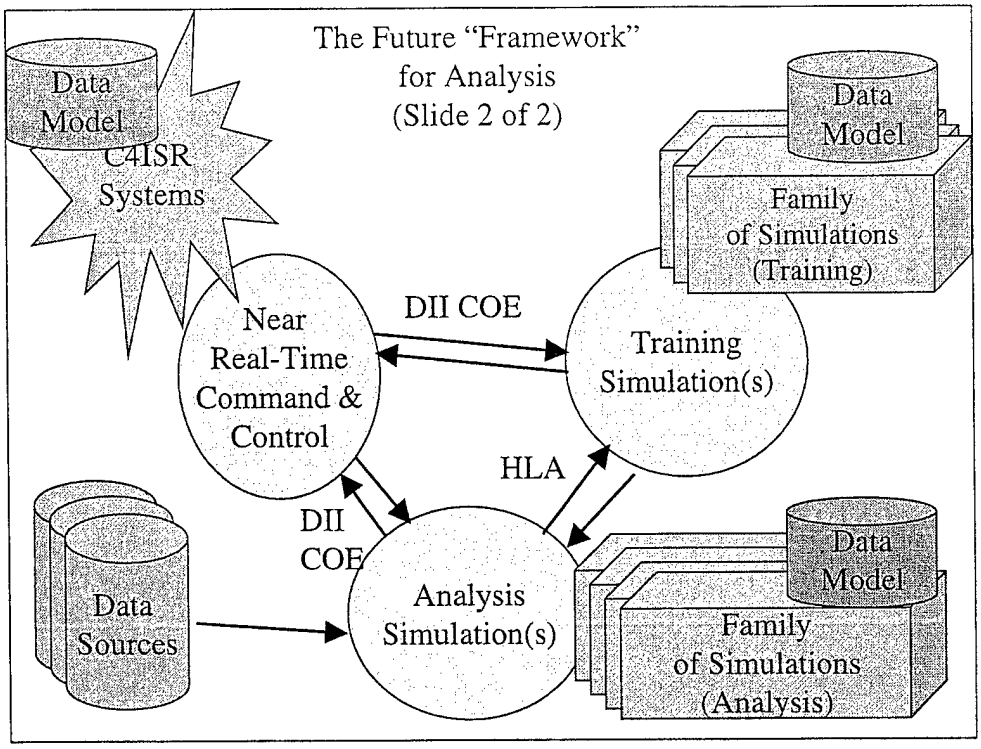
There are three primary nodes in this network of systems. First, there are near real-time command and control systems. These systems are used by operational planners and commanders that are tasked to execute the nation's military missions. In the information age military, they exist in some form or another from the NMCC, down to the soldier in the foxhole. The second node is analysis models. These models, ranging from simple spreadsheets and decision tables to large theater simulations are used to develop and evaluate plans, choose courses of action, and manage the DoD. The final node envisioned consists of training simulations. Again, these simulations vary in scope and complexity.

All of these nodes have a common requirement. They all need data (both primitive and meta) to function. If we are to achieve the envisioned interoperability it is absolutely essential that this data be logically consistent and portable across domains when desired.



One fact that emerged is that the C4I community is embedding decision aids into emerging command and control systems. These decision aids are effectively models that operational staff members and commanders will use to make decisions on those short timelines we see emerging. It is important that analysts (and others) be involved in the development of these algorithms to increase the likelihood that the underlying logic is sound and consistent. Moreover, this kind of involvement is necessary if the DoD is to achieve its objectives with regard to the use of software and achieve a more cost effective maintenance stream for models and data of all types.

In theory the DII COE architecture provides vehicles for data communication from live systems to simulations. However, it was learned that the current data representations in the C4I systems and analytic models will not support this objective. Moreover, there are similar inconsistencies in the data models used between the C4I and training domains.



An example illuminates how this system would improve our operational decision making. Envision a requirement for CINCPAC to deploy humanitarian assistance to East Timor. There is a need to provide logistical infrastructure to rebuild or secure this nation. Also, assume the planning process produced a contingency plan that includes identification of the forces that would be sent on this mission.

The plan and all of its assumptions have been described in some analysis model (Perhaps in an OPLAN Format) and reside in data. At the time the requirement to execute is identified, the data in the plan are compared to ground truth data. The army database on current forces identifies the fact that the 25th Supply and Transport Battalion which was in the plan is not available because it is deployed; and the TRANSCOM data shows that the C-5 that are necessary to meet the timeline are committed to some other high priority mission. What has happened is we have used existing data to quickly illuminate assumptions that were valid at planning time, but are not at execution time. Operators are then quickly able to focus on managing the exceptions.

Added to the previous vision are data models for each of the three primary nodes. It is essential to realize that there are separate and distinct data models that must be aligned and synchronized to achieve interoperability.

The deliberations in the group revealed that there are fundamentally no significant technological impediments to achieving this vision. The obstacles largely relate to achieving a sound common data model, and developing a "cultural will" to expose data to other domains.

WG #4 New Analysis Tools and Methods

Emerging Developments in Analytical Approaches (1 of 6)

- The Army standards category coordination process appears to have potential for improving the consistency of, and access to, modeling resources for analysis and reuse.
  - Air Force and Navy are developing similar approaches.
  - The standards structure provides a foundation for achieving knowledge management.
  - Encodes analysis domain expertise.
  - Could migrate into a best practices compendium.
  - Standards need to be well documented (open peer review, clarity).
  - Process is as (or more) important than the resulting standard.

The Issue is Good Meta-Data

The Army presented their evolving standards category coordination process. It is ongoing and both the Navy and AF have undertaken efforts to develop similar programs. These efforts provide a foundation for KM rules and provides domain area expertise. It is an existing metamodel of analysis domain knowledge. Moreover, the structure provides an emerging link to the training and C4I domains. These efforts are emerging because there is a recognized need to achieve consistency across domains, if other efficiencies promised by technology are to be realized.

The group also provided "seeds" to support further thought on this concept, so that one could possibly avoid some of the pejorative connotations that accompany the term "Standards."

WG #4 New Analysis Tools and Methods

Emerging Developments in Analytical Approaches (2 of 6)

- Conceptual modeling and MSRR efforts appear to provide a good prototype for the content of a DoD M&S knowledge management system with regards to military force behavior:
  - DMSO MSEA investments provide a foundation (direction) for interoperability/consistency.
    - » C4I compatibility is a significant shortcoming (e.g. terrain).
    - » Effort is in early stages.
  - There is a significant issue associated with opaque (undocumented) data generation and transformation.
    - » "Life cycle" costs of models
    - » Data stream
  - IWEDA and NRMM are examples of effective reuse by C4I and analysis.

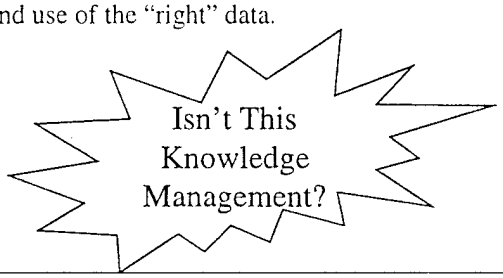
The conceptual modeling and MSRR efforts were identified as a method for encoding force behavior domain knowledge. Group members identified efforts around the community that are similar to the work that was presented. The group identified weaknesses in the technology but each implementation brings the community closer to describing force behavior in a manner that will support more efficient modeling, and consistent data exchange.

Two examples of effective reuse across domains exist in JWARS. One is the Engineer Research and Development Center Vicksburg's application of the NATO Reference Mobility Model in both C4I systems, and simulation. They map characteristics of trucks to trafficability networks. Use of this "model" is also envisioned in WARSIM, the land component of JSIMS. ARL's Integrated Weather Effects Decision Aid (IWEDA) is being used in command and control as well as JWARS. This attempt at reuse identified shortcomings that are now identified research objectives of the Army Research Lab (ARL).

WG #4 New Analysis Tools and Methods

Emerging Developments in Analytical Approaches (3 of 6)

- There are technologies emerging to better "automate" data generation and management.
  - To wit: Army Flow Model and JDS Data Warehouse.
  - We lack a consistent understanding of "source" data and how to propagate it.
  - DoD Standard Data Dictionary is a start.
  - Inconsistency between C4I systems and models.
  - Hope exists (ERDC's NRMM is "consistent").
  - Enables the Distribution and use of the "right" data.



The JDS data warehouse presentation shows technology that can achieve a "central" repository for data management and distribution. Web technologies could in fact be used to distribute this repository so that domain experts retained control over their data.

The Army has a tool called the Flow Model that deconflicts their standard databases — e.g.. lets us know how many trucks are in the army today. This is the kind of information that should be more broadly available to support both planning and execution.

The DoD data dictionary that exists in the C4ISR world is not consistent with the objects typically found in analytical models and simulations.

WG #4 New Analysis Tools and Methods

Emerging Developments in Analytical Approaches (4 of 6)

- There are some "logically sound" prescriptive approaches to supporting decision makers that are emerging or have had staying power.
  - Marine POM decision analysis.
  - CAA's "Analysis in a Rucksack."
  - Features of success are:
    - » Simple, sound logic.
    - » The ability to accommodate multiple stakeholders.
    - » Transparency.
    - » Visualization....consistency and clarity.

The group talked a lot about the need for quick and dirty tools that support decision makers and ability to reduce knowledge to context of decision.

Recommendations vice data.

USMC decision analytic approach is 23 years old. The stuff exists that could be used or adapted for the toolkit.

There are properties of these tools and analyses that cause them to endure.

WG #4 New Analysis Tools and Methods

Emerging Developments in Analytical Approaches (5 of 6)

- The application of "quick and dirty" and "presentation" tools is a weakness in the analytic practice.
- Discipline and commercial tools can contribute.
  - Value focused thinking.
    - » Fundamental objectives (hierarchy).
    - » Means objectives (network).
  - Commercial "modeling" tools.
    - » Logical decisions.
    - » Analytical.... Etc.
- Data issues are a recurring theme.

The manner in which quick and dirty tools are applied is a weakness in the current military OR profession. The historical reliance on large scale combat simulations as the primary "validated" approach to conducting analysis lacks the flexibility to address the broad range of challenges the DoD currently faces.

That said, there are examples of successful analytic projects that do not rely on the large-scale simulations for achieving insight. A common theme of these successful efforts is they are focused on the decision situations most relevant to the decision makers, they are transparent, and they are based on sound, consistent data.

WG #4 New Analysis Tools and Methods

Emerging Developments in Analytical Approaches (6 of 6)

- There are advanced modeling concepts that appear to have some potential for solving some of our "hard" modeling problems.
  - Agent based simulation.
    - » Human decision making.
    - » Soft factors.
  - Mathematical approaches to fusion (sensor and data).

There are some hard problems out there that the group agreed would bear large fruit if we could tackle them and apply some quantitative science to them. Human decision making is not well represented today in analytical processes and models. Finally, there is some highly important Bayesian fusion work that holds the potential to develop sensor and multi-resolution theory. This work will also advance the ability of analysts to study and assess ISR activities.

WG#4 New Analysis Tools and Methods

Potential Applications for Each New Approach

- The identified approaches provide a foundation that can support multi-disciplinary teams in meeting new ANALYSIS challenges.
  - "Warm" consistent data set.
  - "Modular" set of models to draw on and build from.
- There are holes (there always will be).
  - New approaches can be added to the base of knowledge.
  - Commercial tools can provide a "workbench."

Applications: ran some vignettes. Seemed to be able to map to all of them. Want over 50% solution on data, 80% solution on models.

Will always be new analytic challenges. Need to build foundation.

WG #4 New Analysis Tools and Methods

Near Term Recommendations (1 of 3)

- Increase DoD emphasis on supporting inter-service collaboration toward standards.
  - This builds on the existing service efforts.
  - Possible organizational models are:
    - » Existing JTCG (JMEM's) is a possible model.
    - » MSRR board of directors.
  - This should include Joint rules for reconciliation of standards.
  - Establish a baseline (i.e. a minimal standard for meta-data).
- Use limited experience as a foundation for KM implementation.
  - Formal plan for achieving the vision.
    - » Senior leader support and involvement.
    - » Deliberate investment strategy.
    - » Uses the multi-disciplinary team.
    - » There should be a co-evolution of culture and funding for technology.

Work is starting; let's get some resources into it. Needs joint rules to reconcile standards — not saying use same set but must be logically consistent.

Need to build a formal plan not just throw money at the problem and touch all the communities.

As plans become more complete and culture evolves, fund accordingly

WG #4 New Analysis Tools and Methods

Near Term Recommendations (2 of 3)

- The Analysis community should be represented in the DII COE process.
- The DoD should develop and resource a strategy for collecting "other source" data, and applying KM.
  - NTC exercise data.
  - Historical deployment data.
  - Lessons learned data.
  - etc.

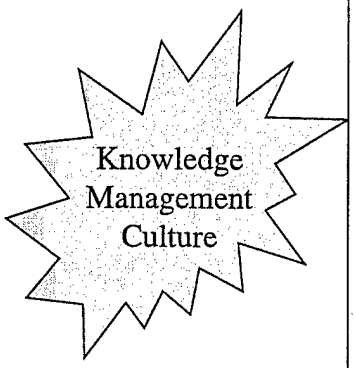
Decision aids being developed in C2. We're either there or miss the opportunity.

Lessons learned hits come from behind the iron curtain.

WG #4 New Analysis Tools and Methods

Near Term Recommendations (3 of 3)

- Encourage the creation and use of "quick and dirty" tools. This should be accompanied by:
  - Rules of the road for using data.
  - Best practices.
  - Mechanisms for:
    - » Timely peer review.
    - » Documenting use.
    - » Allowing evolution.



MORS
MILITARY OPERATIONS RESEARCH SOCIETY

The working group shared a common vision that the community should let "a thousand flowers bloom" with respect to quick and dirty tools that lie outside the formal modeling constructs. These tools hold the potential to free us from the constrained environment of the large-scale simulation and return some speed and flexibility to our science. The problem with this philosophy, however, is to ensure accuracy and consistency in results while allowing flexibility in application.

Rules of the road for using data would allow the sources of data to have a say in the use of their numbers, while a "Best Practices" guide would help to maintain some consistency in approach. Finally, the real value of the KM paradigm comes clear in providing a mechanism for peer review and documenting the usage of technique. This should speed re-use and allow for rapid evolution of technique.

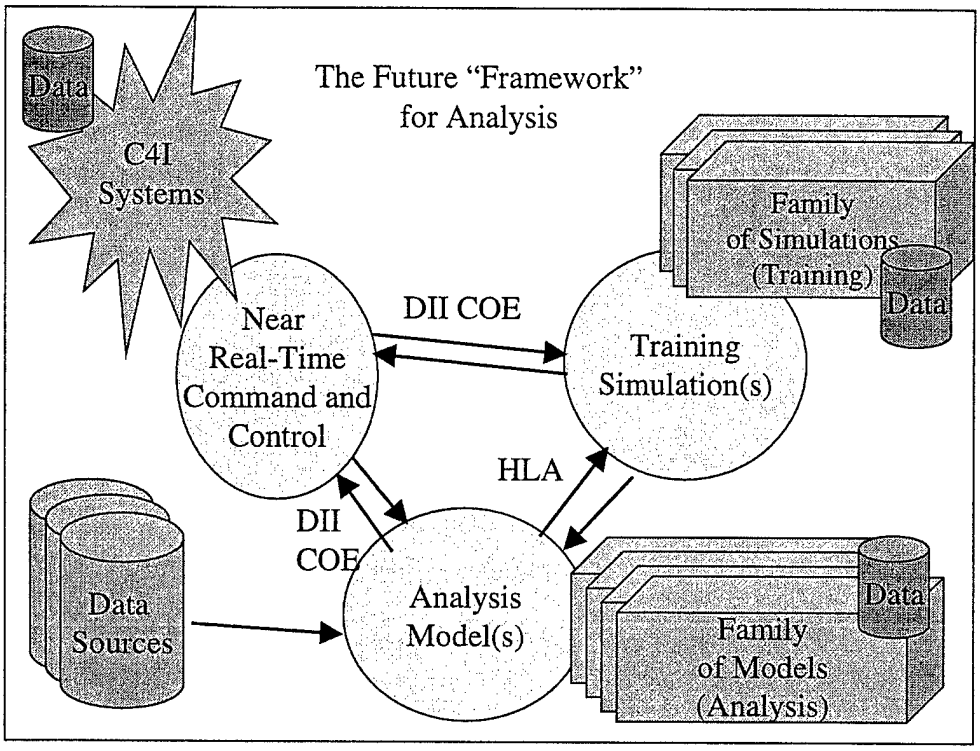
WG #4 New Analysis Tools and Methods

Recommendations for Future Research

- A detailed review should be conducted that maps ongoing research to identified shortcomings:
  - Advanced concepts that "automate" human decision making (C2).
  - Intelligent Agents.
  - Inference/Fusion.
  - Visualization.
  - etc.
- An investment strategy should then be developed to fill the identified holes.

The DoD must invest in the research to allow us to quantify the human decision making process, use intelligent agents, and tackle the fusion problem so as to better represent intelligence processes in analysis. Visualization techniques, both to increase human absorption of information and to yield better displayed information for decision makers, must also be investigated with energy.

The Department must conduct a comprehensive review that maps research into identified shortfalls. We don't know what we don't know, about the basic research being conducted in these areas. Before we create an investment strategy, we need to get the holes right and figure out how to fill them.



The future framework will require a warm bed of consistent data and models that will operate inside the existing decision cycles. The vision is to achieve a fairly seamless linkage between real systems and the families of training and analytical models and simulations.

Each component has its own data (represented in purple) that are particular to its domain and independent of the other areas. This data is highly relevant and important, and must be available to all through the KM paradigm.

Analysis methods are important, but the key to turning around analysis more quickly is data. A warm bed of data, COTS tools, plus a robust training program will help us utilize what we've got. Imbedded tools in C4I systems will generate displays — need to help design these.

Changing the tools will not speed the analysis process alone — we need to change the foundation that we're working with to give more speed. KM is key here. CINCS have existing contingency plans, and analysts often find the closest, most relevant plan to build from. We need a richer set of things to work with, and netted real world and analytical systems in a KM paradigm will give us this.

Over time, models will generate information that becomes another data source. Models would generate new metadata that should be included in this picture. Analysis cases we build can live on the shelf ready for reuse.

MORS Workshop

Evolving the Practice of Military Operations Analysis in DoD

Synthesis Group

Chair: Dr. Stuart Starr

Co-Chairs: Dr. Jerry Kotchka and Dr. Tom Allen

February 29, 2000 through March 2, 2000

Naval Postgraduate School, Monterey, CA

This presentation provides the comments and insights of the Synthesis Group for the "Evolving the Practice of Military Operations Analysis in DoD" workshop as presented during the final session. The Synthesis Group attempted to pull together common themes from all the working groups, as well as to provide insights about how separate themes developed by these groups might be harmonized to support a common vision and meet the overall objectives of the workshop.

Synthesis Team

- Dr. Stu Starr, FS (Chair Synthesis Emeritus) - MITRE
- Dr. Jerry Kotchka - Co-chair - LM/NESS
- Dr. Bob Hinkle (WG-1) - DUSA(OR)
- Dr. Tom Allen (WG-2) - IDA
- Dr. Mike Sovereign (WG-3) - IJWA/NPS
- Dr. Mark Youngren (WG-4) - MITRE
- Dr. Roy Rice (Executive Council Rep) - TBE

Members of the team are listed on this slide. Dr Stu Starr, FS, Working Group Chair, was called away the day before the workshop opened and was unable to attend in person. Despite that, his massive research and coordination with the other working group chairs leading up to the workshop enabled him to gather a great deal of background material, as well as to provide an initial shape to this outbrief. Without his participation and virtual leadership, the final product of the group would have suffered immensely. Dr Jerry Kotchka stepped in to ably coordinate the activity in Monterey. The team included members from each working group and met daily with the chairs and cochairs of those groups, both to highlight common areas and to request effort on specific topics that would help the Synthesis team in their efforts to create a follow-on action plan to help the military operations research community achieve the overall vision of the conference.

Vision

Since analysis is both a product and a process,

our vision is a reemphasized and revitalized practice of analysis

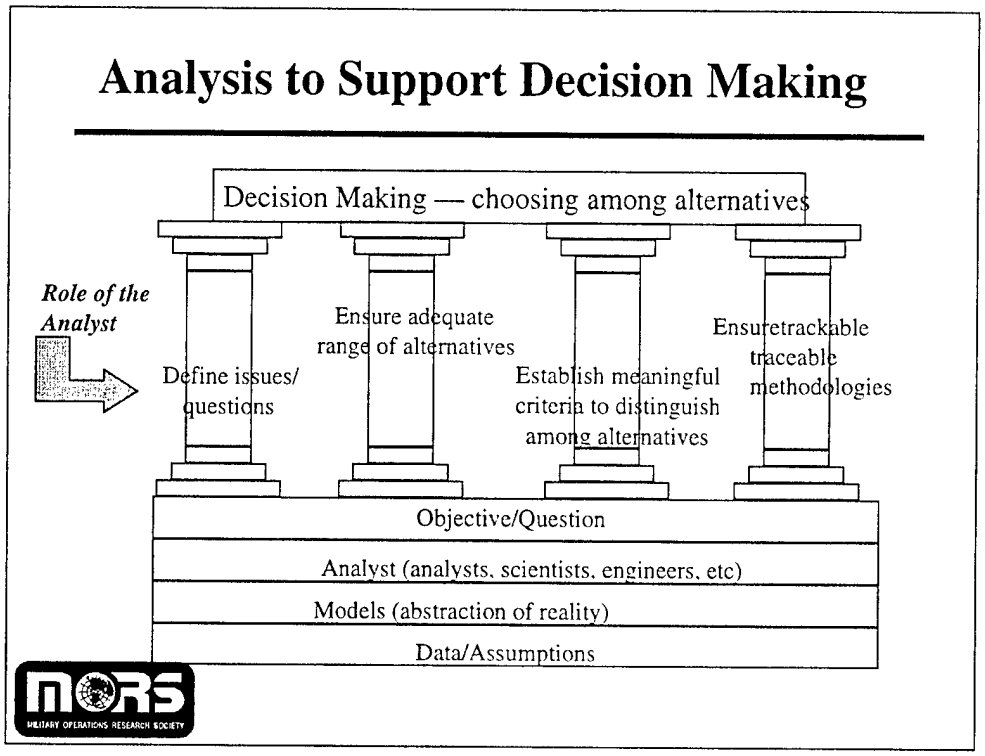
to more effectively and more efficiently

connect the decision maker and analyst

so that

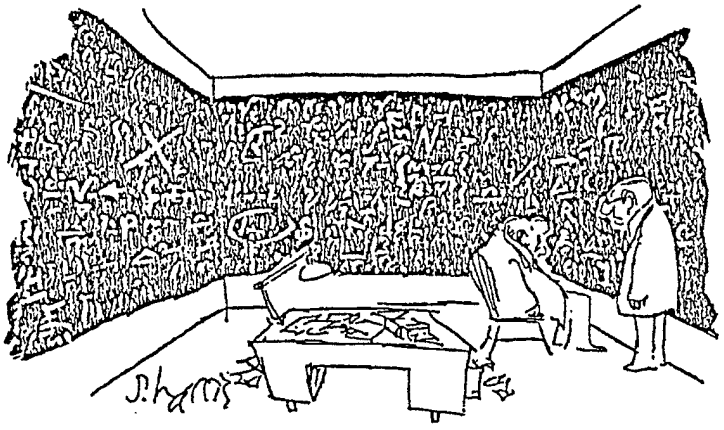
the final product is not the primary result.

Toward this end, the Synthesis Group asked each Working Group (WG) to articulate a vision that would capture the end state resulting from full implementation of their group's recommendations. Based on their inputs, the Synthesis Group articulated the vision shown here. We believe this vision transcends and incorporates the WG visions and describes how emerging capabilities such as collaboration and knowledge management can transform the practice of military analysis. The emergence of powerful communication and computer-based capabilities is already changing the economic world. Where before the focus was on production, the emerging giants of e-commerce are now succeeding through their acquisition and management of information. The most successful and most profitable of these businesses are those that enable the highest level of information sharing, so that opportunities are quickly identified, decisions made based on the full amount of information and insight available in the work force, and then action initiated appropriately. The knowledge resident in every worker is rapidly connected to the decision makers so that timelines are reduced and customer needs satisfied, optimizing company effort and taking full advantage of the knowledge base of the organization. In a like manner, military analysis in the future will need to be fully integrated, with analysts and decision makers so closely linked through technical and personal means that the maximum benefit will flow to the organization. In fact, the interaction will be such that the final results of any study will surprise no one, since decision makers and analysts will both be engaged throughout the analytic process, allowing the strengths and insights of each to be fully incorporated. Such a construct will revitalize the practice of analysis, take advantage of the emerging capabilities, and better address new challenges confronting analysis in the new millennium.



This slide illustrates one view of the current practice of analysis. It shows that analysis is focused on one goal: helping decision makers choose among alternatives. The four elements analysts support in this activity include: 1) helping the decision maker define the issue or questions; 2) helping to define the decision space so that a full range of alternatives can be considered; 3) establishing meaningful measures of effectiveness and criteria that will help show the strengths and weaknesses of the various alternatives; and, 4) then creating understandable, traceable and repeatable methodologies that will assist in this selection process. To do this, an analytic foundation must be in place. This foundation includes the people who contribute to the process, primarily analysts (but including a broad range of other scientists, engineers and subject matter experts); models, or the concepts, mathematical abstractions or other constructs that are used to decompose a problem and focus on key aspects; and the data, scenarios, assumptions and other factors that are necessary to support the process. The issue addressed by this workshop is how this framework is and will be impacted by the changes in the National Security and Technological Landscapes and how the practice of analysis should evolve to handle the challenges and take advantage of the opportunities provided by these changes.

The Analyst's Dilemma



"Whatever happened to elegant solutions?"

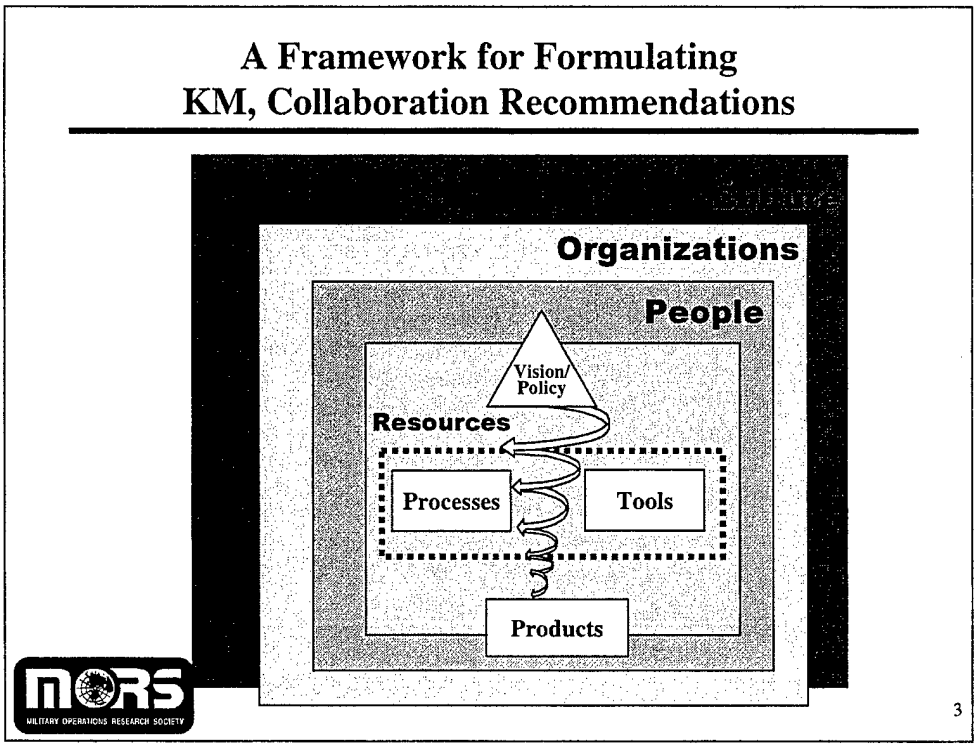
Of course, the very complexities presented by the rapidly changing landscapes associated with this environment may have removed the ability for analysts and others to focus on the big picture. The new environment as assessed by Working Group 3 presents a conundrum: we are asked to provide insight on the complex interrelationships between factors input to and within our models (that reflect interrelationships in the real world), but we are also asked to reduce the complexity and increase the transparency of our tools and analysis. Although it may not be possible or necessary to reduce the complexity of our high-end models (recognizing of course that not all analysis requires large and complex models), open sharing of model data, assumptions, algorithms, etc., all within a set of agreed-upon standards and implemented through knowledge management, may increase the transparency of the models and analysis process *among trained analysts.* The analyst will always have to convert complex mathematical and structured logic into forms understandable to a decision maker without an OR background in all but the simplest cases. Thus, an elegant solution may not be a reduction in complexity to a handful of variables, but instead be a transparency and sharing among analysts that is communicated to the decision maker throughout the analysis (rather than at the end) in a clean and direct (if not elegant) manner.

Definition

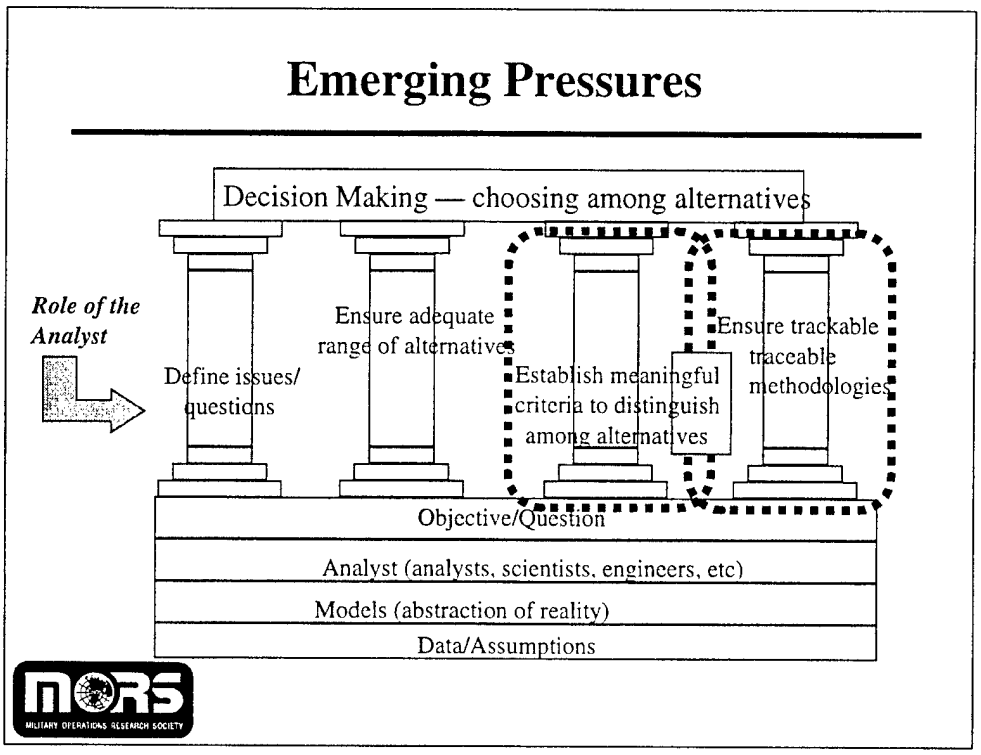
Dr. Ruth David's definition of "Knowledge Management"

- Process through which an enterprise uses its collective intelligence to achieve strategic objectives:
  - » Strategy
  - » People
  - » Process
  - » Technology

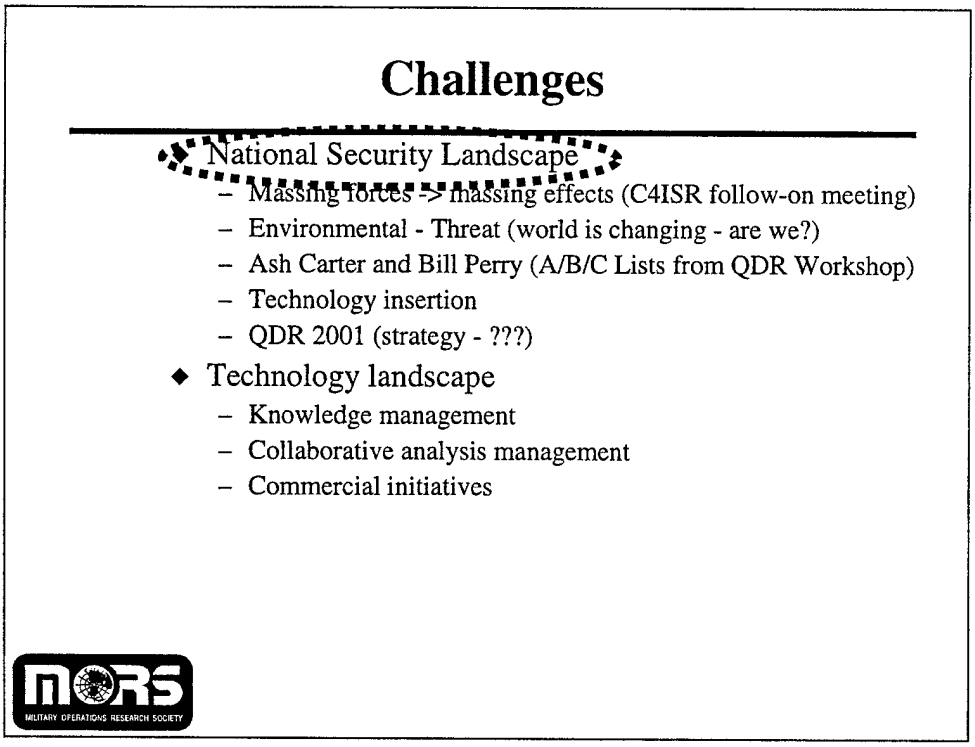
At the same time, there are potential solutions available, at least to address part of the changing environment, and to help our analytic community and other parts of DoD enterprise to adapt and prevail in the emerging environment of the 21st century. Dr. Ruth David, our keynote speaker, defined knowledge management as shown on this slide. Inherent in her definition was the understanding that the enterprise using knowledge management was a "lean, mean, fighting machine team" focused on common objectives and with a shared understanding of the necessity and value of each other's contribution. Such a definition of enterprise may not reflect the current state of DoD, where often mutual contributions are not recognized and parochialism can break down teamwork. However, to the extent that shared goals and team work reflect DoD, and in the areas that knowledge management can help the department move toward this enterprise vision, knowledge management and its implementation surely should be embraced by the department.



The accompanying figure provides a business process re-engineering perspective of collaboration and knowledge management. The Synthesis Group concluded that if we are to successfully implement these capabilities in a dynamic environment, we must consistently address ***all*** of these factors. For example, attempting to field a technology that makes available all information to all members in a culture where classification, close hold consideration of alternatives, and fear that knowledge of a programmatic weakness could result in elimination of a system even if other elements are robust and essential to a military capability, can only result in failure. Before the technology can be designed, the culture must be addressed and pragmatic steps taken to show how such information sharing can actually result in overall benefits to the participating organizations and people. Concrete trust building steps can be followed by bigger steps ultimately implementing the full capability. Just as culture must be addressed, so must the inherent goals and objectives of the involved organizations and people. Many experts at this workshop agreed that the technological solutions for most of the knowledge management and collaboration techniques are already in hand. The biggest challenges will be in addressing the needs of culture, organization and people.

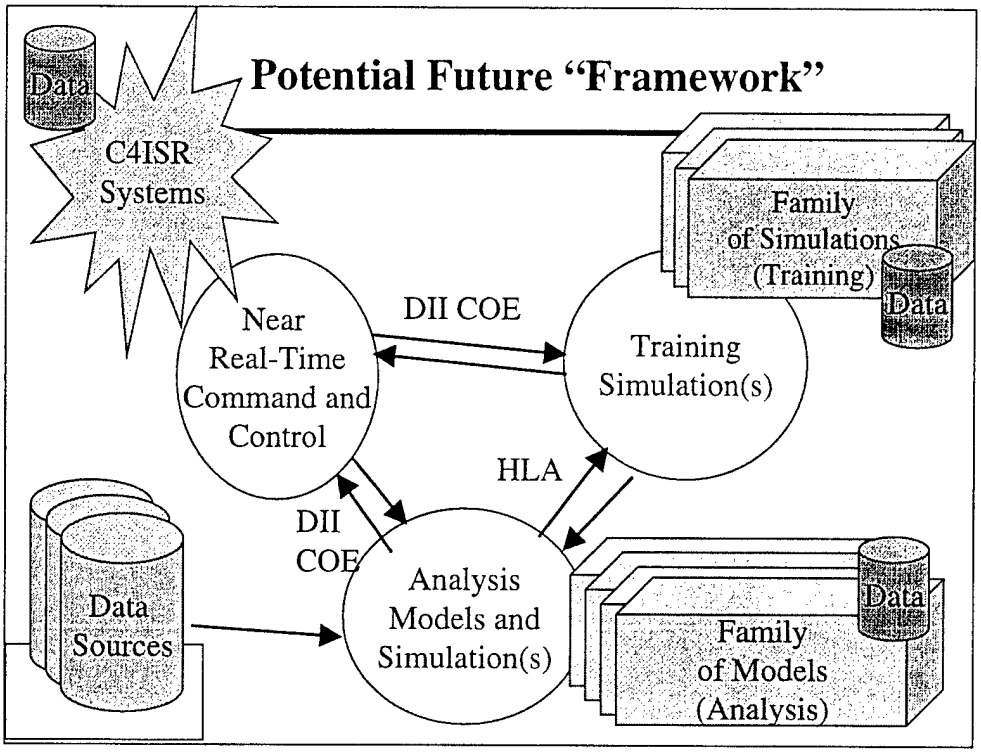


Returning to our analytic construct, we can see that changes in the national security landscape are already shaking some of the analytic pillars. Evolving from attrition-based warfare to effects-based warfare, understanding the implications of C4ISR systems and capabilities, and the emergence of a broad new array of asymmetric threats are all impacting the ability of the analytic community to develop reasonable measures of effectiveness as well as to develop clear and repeatable methodologies to assess these aspects of military activity. While these areas are outlined with the dashed lines (which appear in red in color versions of the chart), the technological landscape and emergence of new capabilities like KM are impacting the rest of the words to potentially transform the way we conduct analysis.



This chart provides more detail on the changes, with the circled "National Security Landscape" reflecting the circled area on the last chart. We've already hinted at the changing paradigm of massed armies meeting on a battlefield to the massing of effects at the appropriate time and place as the way current US military leadership is starting to think about warfare. In fact, to help think through the implications of such changes, MORS has conducted a number of workshops and will hold a C4ISR Follow-on Workshop in the fall to continue to evolve our understanding in this arena. Some of our speakers in this workshop have referred to the Ash Carter/Bill Perry work on who the threats of the future are. They range from an A List of direct threats to national survival which would include homeland attack by catastrophic terror agents, to a B List of threats to national interests that the current strategy seems to address, to a C List of important problems that do not threaten US vital interests (e.g. Kosovo, Somalia). In addition, new technologies require new analytic capabilities to measure the effects and potential contributions from such areas as directed energy, information technologies, unmanned systems and space. The QDR process may change the national military strategy, so the analytic profession will need to be responsive both in helping to determine the implications of strategy shifts as well as in implementing any new strategy in the analyses of the future.

Just as the security landscape is changing, so is the technology environment in which analysis is conducted. This workshop has highlighted KM and collaborative capabilities, but there are a number of other initiatives, such as simulation based acquisition and other e-commerce activities that the analytic community needs to track and adopt where it makes sense to do so.



This slide shows an illustration of an ideal end-state for the current efforts to improve analytical practices. There are three families of models and simulations: M&S embedded in real-time command and control systems; training and exercise support simulations; and models and simulations used to support analysis (to include T&E analysis and analysis of non-warfighting issues such as infrastructure and business process improvement). Within each domain are a set of models and simulations tailored to the purpose at hand. No single model will apply universally across all domains, but in this ideal end state we have data, software objects, and process representations shared across the domains where it is logically consistent with the model and purpose.

Infrastructure programs currently under development are assumed to be in place in this end state, to include the High Level Architecture (HLA) for simulations and the Defense Information Infrastructure Common Operating Environment (DII COE) linking all areas together. HLA federations which may include simulations widely distributed over space will exist where appropriate, but these federations should be standardized and validated for consistency across federates before use. The creation of "on the fly" federations that grab objects and federates scattered across the DII to create unique environments is probably still not possible in this end state because there is no guarantee that the representations will be internally consistent (consistency is not assured even if data is passed through an HLA), and it is unlikely that a single analyst or team located at a single site will be familiar with all of the objects or federates potentially available. Instead, these simulations may be combined through the use of collaborative analysis rather than software linkages.

All of the tools are presumed to be in a bed of warm data. That is, there is a data infrastructure that makes data readily available (with exhaustive metadata explaining the derivation and accredited use of the data) for all of these systems. For example, an analysis of real world capability should be able to draw on the same data set showing current status and deployments of units that a real-time command and control system might use. Similarly, an analysis of a future capability (for example, a 2010 force in a particular scenario) should be able to draw on a validated and commonly used set of data to represent the scenario, system performance, OPFOR performance, etc. Generation and storage of this data requires a significant resource commitment within the Department of Defense, but it is necessary to achieve the desired end state.

A key feature of this environment is that the output of the models, as well as the results of specific analyses and the lessons learned from training and exercises, are also added to the common data base. This provides a useful source of information that can be of particular help to quick turn-around analyses, which may synthesize the outputs of previous models, exercises and analyses.

Tools and Techniques/Challenge Matrix

TOOLS	CHALLENGES					
	New Wars	Behavioral	Support	Interactions	Risk	Non-Model
1. Collaborative Standards	x		x	x		
a. Army Std Category Coord	x		x	x		
b. Conceptual Modeling & MSSR	x		x	x		
2. Automated Data Generation	x		x			
3. Analysts Rucksack	x	?	x		x	x
4. Commercial Analysis Tools		x			x	x
5. Advanced Modeling Concepts						
a. Agent-based Simulation		x		x	?	
b. Fusion models	x	x			x	x
6. Multi-discipline team	x	x		x	x	x
7. Implementation of KM	x	x	x	x		x
8. Environmental MSEA			x	x	x	
9. "Other Source" Info by KM	x	x	x	x	x	x
10. Research on Automated Decisions		x	x	x	x	x

New Wars = Methods for analyzing new domains of Warfare
Behavioral = Inclusion of behavioral factors in current models
Support= Measure combat impact of support (Log, C4ISR, OPTEMPO, Readiness etc)
Interactions = Identifying complex interrelationships between factors
Risk= Quantification of risk and uncertainty
Non Model= Reduce the model centricity of analysis

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Part of the improved environmental end state is the development of new tools, techniques and methodologies to address the specific challenges of the future. Some of the new or emerging tools and techniques identified by Working Group (WG) 4 are shown on this chart to illustrate which show promise to address, at least in part, the challenges identified by Working Group 3. Those challenges fell into 6 broad categories: 1) changing characteristics of warfare in the 21st Century (New Wars); 2) inclusion of the effects of humans and human factors (e.g., morale, training) into models (Behavioral); 3) showing the effect of logistics and other support activities on warfighting outcomes (Support); 4) identification of complex interrelationships between input variables and between internal variables (processes) within models (Interactions); 5) explicit quantification of risk and uncertainty in analysis and in communications with decision makers (Risk); and, 6) the challenge of developing and gaining acceptance of analysis techniques that are not dependent upon traditional simulation or other models (e.g., linear programs) (Non Model).

WG 4 identified many recommendations regarding new or emerging tools and techniques that should be explored and implemented where appropriate. These tools and techniques fell into 10 categories as shown above. The first category listed involves standards. There are some relatively new efforts underway to develop common standards that can be applied to the models and data used to support analysis; the Army Standards Category Coordination process is one example of this. DMSO sponsored efforts to develop common conceptual models and M&S Resource Repositories (MSRR) is another example. The group recommended that the fundamental algorithms underpinning many major

simulations in use be examined in open (peer review) forums and reconciled. Although a commonly accepted set of algorithms would be desirable, it is not necessary that all services or other users agree to a single representation of a warfare phenomena. We can agree to disagree, provided the differences are clearly documented, understood and made available to the analysis community.

The second technique identified by WG 4 is automated data generation. The biggest single complaint from the working group was the lack of needed data and the difficulty and cost of generating or obtaining data even when it is available. Automated means of generating commonly used data would increase the responsiveness and reduce the cost of getting the data.

The "Analyst's Rucksack" is an example of using quick and simple tools and decision aids to fill in for large model deficiencies and directly support warfighters. The Workshop endorsed the development of tool sets of this nature.

The commercial world is also producing an array of tools that have great utility for operations research analysts. Tools which have been around for several years, but are becoming increasingly sophisticated and easy to use, include statistical and data analysis packages, linear and nonlinear programming, process simulation and decision analysis software. Emerging products include neural networks, Bayes nets, colored Petri nets and other software that propagate inferences or influences.

There is recent research that is producing some new techniques that may be applied to fix, in part, some of the areas that lack tools for analysis. Agent-based simulation may help in the analysis of doctrine, procedures and risk sensitivity, and recent mathematical models have been developed to assist in the simulation (and real world execution) of fusion between multiple sensors and sensor disciplines. This is not an exhaustive list, but are two areas that show promise.

Performing analysis in the 21st century will likely lead to the resurgence of the multi-disciplinary team. However, this team will have a different composition than the teams in the early days of military OR, which were largely formed from hard sciences. Although some problems may still require physicists, chemists, etc., most work will require groups pulled from 3 broad areas. The first consists of domain experts, which will often include warfighters, doctrinal experts, and other expertise in military operations. The second group are software and computing experts, as models and tools become increasingly complex from a software perspective. The third group, which helps to meld the other two together, consists of operations research analysts and other experts from related analysis domains, such as mathematics and statistics. We should no longer expect that a single military OR analyst be able to read and write code, develop mathematical models and possess a broad military background to include joint operations.

The implementation of knowledge management techniques identified by WG 1 and presented by plenary session and lunchtime speakers will also help address the challenges to the practice of OR. These concepts are developed in detail in other sections of this report.

Modeling and Simulation Executive Agents (MSEA) have, in some areas, greatly advanced the state of the art in M&S. The environmental MSEAs have had a great degree of success and can serve as exemplars of the process that leads to significant improvements. They have developed data standards applicable to a wide variety of simulations (to include both training and analysis simulations) and real world command and control systems, and populated these data structures with data that is easily obtained through user-friendly business processes. They have also developed algorithms to transform the data into information useful to aggregated models; for example, the Army has developed techniques for automatically generating road networks from detailed NATO-standard mobility networks.

One area that can be addressed through good knowledge management practices involves "other source" information. This data includes NTC exercise data, historical deployment data and "lessons learned" data. These data sometimes exist but are not necessarily recorded for posterity (e.g., much NTC information is outbriefed to the unit commander and then deliberately destroyed), not captured at all (e.g., historical deployment data), or are captured only qualitatively rather than quantitatively (e.g., lessons learned). These data, if resources are applied for capture and storage, can significantly improve our ability to validate models against "real world[1]" experiences.

Finally, the group recommended that additional research be made in the area of automated decision making. Large simulation models require some automated representation of a human decision maker (e.g., a commander and staff in an analysis model or an OPFOR or subordinate commander in a training model) to provide reproducibility or reducing exercise/training costs. However, the current implementations are recognized to be insufficient and unrealistic. Automated decision making can also be embedded in real time decision aids, not to replace a human decision maker but to advise him or her.

[1] We recognize that exercise data is not real combat data, but it is a useful surrogate that may be more accurate than outputs from abstract model and simulations.

Endorsement

KNOWLEDGE MANAGEMENT HAS THE POTENTIAL TO ENHANCE OPERATIONS ANALYSIS

Distinguishes "what we know, what we don't know"

Enhances Information Sharing and Collaboration

Addresses the "Knowledge is Power" Paradigm

While concepts associated with specific challenges were shown on the last slide, the Synthesis Group also felt that knowledge management can offer a more general solution to the broad issues confronting analysis as well. Some aspects of KM can already be endorsed in ways that do not threaten existing culture. In particular, KM has the ability to help distinguish between what we know and what we don't know by helping the enterprise quickly tap the collective knowledge of individuals in the organization. This capability can provide an individual assigned to work a problem the capacity to quickly poll all experts in or out of the organization to assess what is already known or what is in the process of being studied about the problem. In fact, a properly implemented KM system will save enormous time and resources by helping the analyst and others rapidly determine what is already known as the basic starting point of any study. The same system, by enabling rapid connectivity between analytic practitioners, will also enhance information sharing and collaboration. When a study team, already focused on a specific area, realizes that the value of its research can be increased by adding just a small amount of effort in order to address a broader range of questions to meet the needs of a broader customer base, one promise of KM will be realized. And as the limited resources available in an organization self-organize to focus on the areas they do best in order to provide a broader base of insight and information to the organization, the people involved will clearly understand that their value-added is not in hoarding information, but rather in developing and sharing it in ways that enhance the overall capabilities of the enterprise. Value added will not come from just having information, since in the future information will be increasingly available to everyone; increased value added will instead come from the ability of individuals and organizations to share available information creatively to enhance the capabilities of the organization.

Action Plan

	Near	Mid	Far
MORS	- Update MORS Membership Directory/Database - Evolve role of Electronic Media Committee - Contribute to Code of Best Practices for Joint Experimentation	- Focused Workshop Activity	- Education Colloquium address idea about KM Professional Development
DoD	- Working Group recommendations are included as a backup to this briefing and provide a phased approach to KM and collaboration implementation by focusing on people, process, technology and product, as well as list challenges and promising tools and methodologies to meet those challenges		

The Synthesis Group identified a number of actions, some of which are shown here, that should become part of a long range action plan that the community should consider and flesh out over the next few years as it evolves the practice of military analysis in DoD. In particular, there are several steps that MORS itself can implement immediately that will have enormous potential to improve the ability of this community to connect with each other and better meet the over all needs of its membership. In addition to the items shown here, the working groups provided a number of general and specific steps that will help the community learn to harness KM and collaboration as well as to address emerging issues in the changing security environment. Generalized recommendations endorsed by the Workshop include working the people, process and technology problems in order to ensure a better final product.

Summary Recommendations

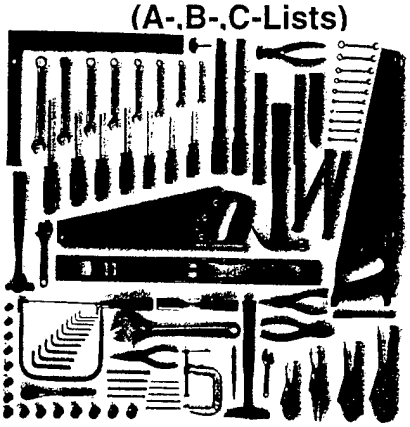
- Vision/policy: develop and promulgate enterprise Vision, strategic directions.
- Culture: take action to remove deeply rooted cultural barriers (e.g., dispel the myth that "knowledge is power").
- Organization: Ensure top management buy-in.
- People: provide incentives to analysts to collaborate and share knowledge.
- Processes: institutionalize processes to enhance collaboration and the sharing of tacit, explicit knowledge among analysts.
- Analytic Tools:
  - Develop and emphasize joint standards in algorithm and data development.
  - Take action for developing and maintaining data warehouses.
  - Focus basic research and tool development to meet emerging pressures and challenges.

This chart summarizes the focus and potential impact of the specific actions recommended. First, cultural changes are a necessary prerequisite to effective transformation of the analysis community (e.g., the need to dispel the myth that "knowledge is power"). Second are several organizational issues that must be addressed. One of these is to ensure top management buys in to this transformation. Another includes reassessing how security issues can be addressed in an information centric, open environment. In the third area, decision makers must recognize that the analysts involved in all phases of the assessment process constitute a critical intellectual resource. They must be given incentives to stimulate them to contribute and draw from future knowledge warehouses. Tying all this together are the links between the vision and the high level guidance to the analysis process and the primary products of that process (i.e., effective, timely, rigorous analyses). To implement this linkage, a set of enhanced processes is needed (e.g., institutionalized processes to diffuse tacit and explicit knowledge) supported by a broad set of tools (e.g., knowledge warehouses, collaboration tools). These processes and tools are constrained by available resources (e.g., funds, manpower) such that a special funding mechanism may be required to satisfy time urgent joint needs. In particular, basic research must be continued in those areas where understanding of phenomenology is not available (human decision processes, IO/IW, etc) as well as the continuing development of analysis tools to address the emerging challenges.

Our Ultimate Goal

Current
(B-List)
Where we are

Where we're headed
Desired
(A-,B-,C-Lists)



The Synthesis Group feels that by addressing the needs of the community to implement our vision, the practice of analysis can evolve from its current position of a limited toolkit and methodologies to address a limited number of issues to a complete tool set connecting analysts and decision makers to address the full array of national security challenges.

Back Up Slides

WG #1 Management of Analytic Knowledge

Recommendations (Page 1 of 7)

- The DoD Sponsor implement knowledge management techniques, particularly to establish an intranet portal, in support of an important study with suitable scope, schedule, and content that partners DoD components Military Operations Research Society, industry and academia. The elements that should be considered along with strategy already discussed include:
  - People
  - Process
  - Technology

This is our overarching recommendation, which detailed in the next series of slides under the headings of:

Strategy

People

Process

Technology

Specific organizations that should be included are the Services, OASD(C3I), DTIC, MSIAC, DMDC, DMSO.

WG #1 Management of Analytic Knowledge

Recommendations (Page 2 of 7)

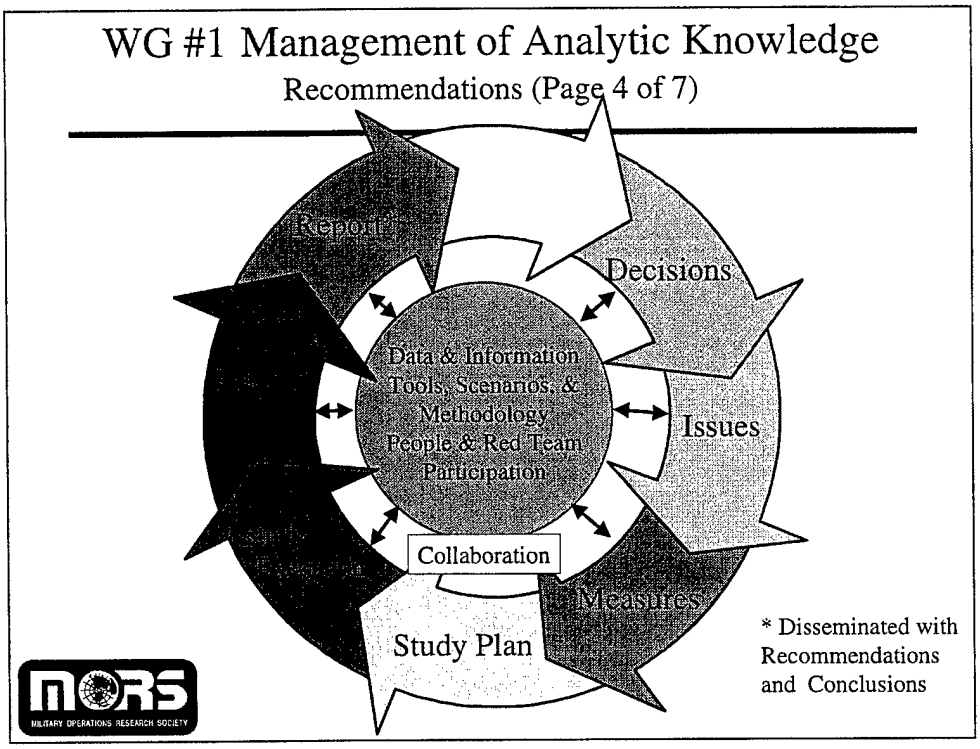
- People
  - DoD and MORS lead an assessment of the capability to provide a baseline inventory of analysts for DoD operations research studies.
  - MORS assess its capability to establish a knowledge management professional development program for the DoD analytic enterprise that would include the identification of skills and products, the refinement of skill levels, and the training of analysts.
  - The DoD Sponsor evaluate successful skill-inventory systems (e.g. Northrop-Grumman and Y2K) for implementation within the DoD Analytic Enterprise.

Industry experience and DoD case studies show that people is one of the most critical success factors associated with KM. The recommendations cited here are designed to provide the fundamental foundation for organizing and educating people using KM techniques being applied by industry. Key DoD organizations that could be involved in pursing this recommendation include ASD (C3I), DUSD(P&R), OSD(PA&E) and DMDC.

WG #1 Management of Analytic Knowledge

Recommendations (Page 3 of 7)

- Process:
  - J-8 accept leadership with OASD(C3I) of an evolving analysis process for the purpose of improving analysis in a future analysis state. Notionally, the evolving process could be closely interfaced with an evolving knowledge management process as shown on the next slide.



The working group recognized that the future (to-be) process incorporating KM is still to be defined. Nevertheless, this slide helps illustrate the important interrelationships related to collaboration, creation, and reuse of a well constructed analytical KM environment and extensible knowledge base.

WG #1 Management of Analytic Knowledge

Recommendations (Page 5 of 7)

- Process continued:
  - The DoD determine the business rules for contributing analytic knowledge. For example, what are the current rules that control the access to past studies and how could these rules be changed to improve access such as those stored at Federally Funded Research and Development Centers. A special case is the identification of the business rules for administering and controlling an analyst's portal.
  - The DoD Sponsor, with the assistance of MORS, identify new types of information required for future analyses (e.g. foreign demographics, information warfare related, economic information, national infrastructure related, chemical/biological, etc.)
  - The DoD Sponsor identify current Centers of Expertise required for improved analyses.

The working group concluded that the first bullet was probably the most critical follow-on task for DoD to tackle. If this is not done, KM will fail.

WG #1 Management of Analytic Knowledge

Recommendations (Page 6 of 7)

- Process continued:
  - Take steps to systematize the organization of information by transposing principles from traditional library and information sciences to the electronic realm.
  - Develop and use an Information Architecture that structures the design of information organization, labeling, navigation and indexing systems to support both browsing and searching.
  - Identify and use a set of metrics for the business case preparation and performance evaluation of the analyst's portal.
  - Create knowledge-sharing incentives such as:
    - » Knowledge-sharing inclusive performance reviews
    - » Embedded authorial recognition

The importance of performance reviews and embedded are mentioned repeatedly in the literature. The study done by the Working Council for the Chief Information Officers strongly supports this point. This study also stressed the importance of having an information architecture for effective design and administration of browser-enabled knowledge-based repositories.

WG #1 Management of Analytic Knowledge

Recommendations (Page 7 of 7)

- Technology
  - The DoD concentrate on applying COTS tools as a key critical success factor for building analytical KM portal. Example technologies include:
    - » Thesaural browsers.
    - » Personalized intranet portal.
    - » Knowledge-sharing inclusive performance reviews.
    - » Federated knowledge management .
    - » Information-expiration mechanisms.

WG #2 Enabling Collaboration
Recommendations

- **People**
  - Find ways to identify (and evaluate?) Subject Matter Experts (SMEs).
  - Find a means to develop operational experience in Civil Service 1515s and uniformed analysts w/o warfighting specialties.
- **Process**
  - There is a spectrum of Collaborative analysis processes, and each has its strengths and weaknesses (bold shifts versus consensus).
    - » Can organize for competitive analyses.
    - » Can organize to search for a "common ground" solution.
  - Collaborative Analysis is a "team sport" and requires practice.
    - » OA Support to Commanders in the field most effective when "Train as you Fight" has been implemented.

Our recommendations have been collected under the headings of "People," "Process" and "Product."

WG #2 Enabling Collaboration

Recommendations

- **Process** (continued)
  - Reestablish formal liaison/exchanges to improve the quality of collaborative analysis
  - Support independent, accredited sources for data to speed collaborative effort.
  - Find ways to identify data to source new applications and phenomena.
  - Data collection must be deliberate and done in such a way that it does not require additional effort by operators.
  - Synchronize data production with data demands and institutionalize production and update of long-lead items.
    - » E.g., extend JMEM to include developmental systems.
  - Harmonize schedule of major collaborative projects and Service workload.

WG #2 Enabling Collaboration

Recommendations

- **Product**
  - Need improvements in literature search capabilities, identifying work in progress that may affect the project at hand.
  - Study documentation techniques must also improve, allowing for reproducibility of results and reuse of data in addition to description of procedure and findings.

WG #3 New Analysis Challenges
Recommendations

- Find methods to deal with.
  - New forms of operations.
  - Traceability of known factors and interactions.
  - Quick turn-around studies.
- Nurture analysts and analytical thinking rather than focusing on model development.
  - Project more balanced view of model capabilities and limitations.
  - Reverse trend to big models as solution to all problems.
- Characterize and communicate impact of uncertainties (e.g., Risk, behavioral factors).

In summary, as the analytical community evolves it needs to find tools to deal with new forms of operations, find methods to trace known factors and interactions to their logical combat output and find tools that will provide accurate and thorough analysis in a short timeline.

The DoD analytical community needs to nurture analysts and emphasize analytical thinking rather than focusing on simulation and modeling development. The community must project a more balanced view of model capabilities as well as limitations, and reverse the recent trend toward blind faith toward large models as the solution to all analytical problems.

The analytical community needs to find means for characterizing and communicating the impacts of uncertainty. For example risk, such as decision risk based on the fact that various factors may not have been considered in the current analysis, need to be characterized and communicated to the decision maker,the analytical product customer.

WG #4 New Analysis Tools and Methods

Near Term Recommendations (1 of 3)

- Increase DoD emphasis on supporting inter-service collaboration toward standards.
  - This builds on the existing service efforts.
  - Possible Organizational Models Are:
    - » Existing JTCG (JMEM's) is a possible model.
    - » MSRR Board of Directors.
  - This should include Joint rules for reconciliation of standards.
  - Establish a Baseline (i.e. a minimal standard for meta-data).
- Use limited experience as a foundation for KM implementation.
  - Formal plan for achieving the vision.
    - » Senior Leader Support and involvement.
    - » Deliberate Investment Strategy
    - » Uses the Multi-disciplinary team.
    - » There should be a co-evolution of culture and funding for technology.

WG #4 New Analysis Tools and Methods

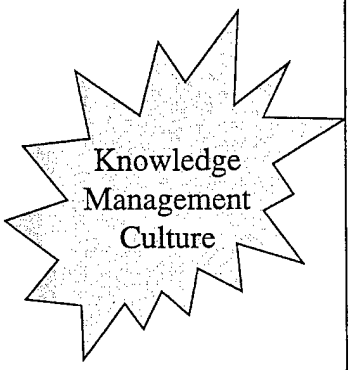
Near Term Recommendations (2 of 3)

- The Analysis community should be represented in the DII COE process.
- The DoD should develop and resource a strategy for collecting "other source" data and applying KM.
  - NTC exercise data.
  - Historical deployment data.
  - Lessons learned data.
  - etc.

WG #4 New Analysis Tools and Methods

Near Term Recommendations (3 of 3)

- Encourage the creation and use of "quick and dirty" tools. This should be accompanied by:
  - Rules of the road for using data.
  - Best Practices.
  - Mechanisms for:
    - » Timely peer review.
    - » Documenting use.
    - » Allowing evolution.



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WG #4 New Analysis Tools and Methods

Recommendations for Future Research

- A detailed review should be conducted that maps ongoing research to identified shortcomings.
  - Advanced Concepts that "automate" human decision-making (C2).
  - Intelligent agents.
  - Inference/fusion.
  - Visualization.
  - etc.
- An investment strategy should then be developed to fill the identified holes.

TERMS OF REFERENCE

Evolving the Practice of Military Operations Analysis in DoD Applying Knowledge Management

1. Background

Leaders in the DoD analysis community are calling for an examination of how we perform analyses. They are asking us whether our analysis practices warrant examination with a view towards improving their effectiveness.

The management of knowledge, how to prepare to perform the next analysis, how to perform the next analysis, how to gather information needed to support analysis, and how to find and apply analytic insights from recent studies, is becoming a principal factor in being able to meet decisionmakers' expectations in regard to both the quality of an analysis and the speed with which an analysis is accomplished.

Making Analysis Relevant[1] was the topic of a *PHALANX* article by Mr Vince Roske in early 1998. Mr Roske reiterated a recipe provided by John D. (Dave) Robinson, MG USA, Ret, when he was the Director of J-8. The recipe is provided below.

- *What's the question?*
- *What's the "real" question?*
- *What do the final slides look like?*
- *What do I already know?*
- *How do I get the remaining information that I need?*

Dave Robinson's recipe is reminiscent of the very practical battle drills used by the military to train soldiers to do basic tasks. It is simple, it is memorable, and it will get the job done. Mr Roske goes on to look deeper at each of the recipe steps and discusses the issues associated with performing analysis today. He explains that we must focus on the purpose of the analysis and not become wed to models that don't fit the analysis. Furthermore, he explains what the analyst must do to keep the analysis relevant to the decision maker.

The Revolution in Analytical Affairs[2] is described and discussed by LTG Dave Heebner in his excellent *PHALANX* article published later in 1998. He emphasizes many of the same points that Mr Roske focused on. In particular he cites the need to pin down the decisionmaker's questions early, and provide the needed findings, recommendations, and insights as quickly as possible.

2. Discussion

The first three steps in General Robinson's recipe address critical steps in organizing and focusing an analysis or study. Answering *"What's the question?"* and *"What's the "real" question?"* enables the analyst to frame a study so that there is a chance that it may ultimately be relevant to the needs of the decision maker. Answering *"What do the final slides look like?"* up front serves the dual purpose of stressing the importance of communicating results to the decisionmaker and focusing the analysis efforts from the beginning.

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[1] Mr Vincent P. Roske, Jr., "Making Analysis Relevant," *PHALANX* Volume 31, Number 1, March 1998

[2] LTG David K. Heebner USA, "Revolution in Analytical Affairs," *PHALANX* Volume 31, Number 3, September 1998

But the substantive content of the analysis is contained in the last two recipe steps: "What do I already know?" and "How do I get the remaining information I need?" Evolving the Practice of Military Operations Analysis in DoD must therefore substantively address these last two questions.

One of the keys to successfully evolving the practice of analysis is the innovative management and application of knowledge, both tacit (the knowledge in the minds of the experts) and explicit (the knowledge that is recorded in various ways). There is an explosion of new thinking and new supporting technology to capture and apply knowledge more effectively. This area includes innovation in the discovery, expansion, capture, organization, and sharing of knowledge. Innovations include: correlation landscapes, data mining tools, virtual information centers and influence diagrams

For a discussion of the emerging field of Knowledge Management see Appendix A.

For a bibliography of Knowledge Management information sources see Appendix B.

The keys to effective analysis in DoD are the analysts, the knowledge that analysts access, the process by which analysts perform their work, the tools that analysts employ to perform their work, and the effectiveness with which analysts communicate analytical results to decisionmakers. Analysts and subject matter experts have important and relevant knowledge in their heads – tacit knowledge – that could spark important insights among their peers if it were available to them.

Information is a source for good decisionmaking, however, a piece of information is more valuable when presented in context, that is, with other pieces of related information that make the original information more meaningful and actionable. For instance, a study of the effectiveness of a proposed ISR system may provide important information, but it is much more meaningful and actionable when analyzed in the context of national security policy and DoD objectives and when related to operational outcomes.

In DoD, we analysts don't know what we know, and consequently, we are bound to reinvent the wheel many times. We do not have automated enterprise repositories which hold accessible, important, explicit knowledge nor do we have the means to locate the right subject matter experts quickly and easily to access their tacit knowledge.

The proper management of knowledge can improve analytical efficiency by providing a framework, tools, and techniques to reuse intellectual assets. By marshalling resources to respond to opportunities and threats, our responsiveness could be vastly improved. And by bringing people together across time and geography to share ideas and insight, intellectual innovation can flourish and bear richer insight for decision makers.

This special meeting, comprising analysts and subject matter experts in approaches to analysis, will concentrate on the improvement of the analysis practice throughout DoD. To achieve this end, participants will enumerate potential issues related to a broad move towards more collaborative analysis and enterprise knowledge management and define the appropriate policies, organizational structure, processes, technologies and training needed to institutionalize an improved practice of analysis in DoD. These issues will be addressed by working groups, addressing the spectrum of dimensions of organizational change, as well as supporting infrastructures and supporting tools and techniques.

3. Goals and Objectives

The body of analytical methods, techniques, and tools and how we apply them will be the focus of this workshop. We will be examining how we carry out our professional work and the need to evolve. Questions to be addressed include:

- What should be the customary manner for performing defense-related analyses?
- How do we manage the knowledge we derive from our analyses?
- How do we support both fast turn-around and more deliberate analyses?

- What problems are not well served by the current state of the practice?
- What innovative developments in analysis tools and methods, including Knowledge Management, hold potential value for DoD analysis?

3.1 Goals

This workshop will afford the military OR community an opportunity to achieve the following goals:

(1) Develop a shared understanding of the need to evolve the practice of Military Operations Analysis in DoD;

(2) Establish a vision for improving analytic practice and the management of supporting analytic knowledge in DoD;

(3) Create a plan to realize the vision to improve analytic practice and the management of supporting analytic knowledge in DoD; and

(4) Define how MORS may work with the sponsors over time to implement improvements to analytic practice and to the management of analytic knowledge in DoD.

3.2 Objectives

The objectives are to:

- Define a desired analytic practice approach in DoD in terms of policy, organization, process, technology, and training.
- Define current analytic practice in DoD in terms of policy, organization, process, technology, and training.
- Identify weaknesses in the current practice relative to current and future requirements.
- Produce an actionable plan to move to the desired state.
- Define mechanisms to be established within MORS to work with the DoD sponsors to execute the plan.

4. Approach

In order to achieve these goals and objectives, the subject of analytic practice will be examined in a number of different contexts. Working groups will examine analytic practice within each contextual framework. Working groups will be asked to address some baseline issues (as a starting point) and provide specific results. The working group contexts, baseline issues, and desired results are detailed below.

4.1 Working Groups

The workshop attendees will be organized into four domain working groups (25 to 30 members each) plus a synthesis group:

- **Management of Analytic Knowledge**
  - Examine the manner in which analytic knowledge is discovered, expanded, organized, and shared.
- **Enabling Collaboration**
  - Examine the process, tools, and techniques that support distributed analytic teams in performing analytic tasks.
- **New Analysis Challenges**

- Examine military operations analysis questions of interest for which the established military operations analysis community apparently does not have answers.

- **New Analysis Tools and Methods**
  - Examine emerging developments in analytical approaches to complex systems to assess potential applications to challenging military operations analysis probleMs
- **Synthesis**
  - Discover the common themes that tie together the efforts of the four subject area working groups and provide feedback to the groups on a continuing basis.

4.1.1 Working Group 1: Management of Analytic Knowledge Working Group

Chair: Mr Mike Yoemans
Co-Chair: MAJ Willie McFadden

This working group will examine the literature that is beginning to define the field of knowledge management. The group will examine the manner in which analytic knowledge is discovered, expanded, organized, and shared. Also addressed will be intelligent search engine technology and intelligent agent technology and how these techniques leverage web-based stored data to meet real-time analysis requirements. The group will produce a summary report defining how these technologies may be incorporated into existing analytic practice.

4.1.2 Working Group 2: Enabling Collaboration Working Group

Chair: COL Bob Clemence
Co-Chair: Lt Col Kirk Yost

This working group will examine collaboration techniques. Particular attention will be paid to policy, procedure, and technique to support collaboration once expertise has been identified. While efforts to promote collaboration are ongoing, there are still opportunities to improve the sharing of information, expertise, and insights. Early techniques supporting collaboration are maturing and new techniques are emerging. The group will also examine expertise location techniques. Particular attention will be paid to policy, procedure, and technique to enable the development and maintenance of a DoD-wide means to find, catalog, and make available analysis expertise and subject matter expertise. Attention should be paid to the dilemma organizations face in gaining the willing cooperation of its most knowledgeable members in seeking organizational improvement. The group will produce a summary report defining how expert knowledge may be shared to support analytic practice.

4.1.3 Working Group 3: New Analysis Challenges

Chair: Dr Steve Pilnick
Co-Chair: Maj Suzanne Beers

This working group is about new problems, problems not involving conventional warfare, and/or post-Cold War probleMs Actually there are old problems that belong here as well. The issue isn't whether the problem is new or old, but rather whether the Military OR community has succeeded in addressing it satisfactorily. An example is the problem of determining the value of a common operating picture to the warfighter. Presentations in this working group should come from the major analysis players like PA&E and the Services' Studies and Analysis shops, from the warfighters like Joint Force Command and CINCPAC, and from decision makers like OSD, J8, and the Services' warfare requirements and assessment organizations. The group will produce a summary report describing the analytic problem domains explored,

the problem domains that may be addressed with known techniques, and the problem domains that might be well-served by the development of new analytic techniques. This working group will consult with Working Group 4 throughout the Workshop to ensure that new analysis challenges and new analysis tools and methods are shared between the two working groups as their work proceeds.

4.1.4 Working Group 4: New Analysis Tools and Methods

Chair: LTC Dan Maxwell
Co-Chair: Dr Al Brandstein

This working group should hear about chaos, complexity theory, complex adaptive systems, agent-based modeling, and other emerging methods for analyzing complex systeMs The working group should brainstorm potential Military Operations Analysis in DoD applications of each new approach considered and attempt to assess the potential of such new methods to deal with analysis challenges identified in Working Group 3. The group will produce a summary report describing the classes of tools and methods explored, and the Working Group's ideas about the classes of problems that may be addressed with these tools and methods. The Working Group report should be useful as an outline of a research agenda for next generation military OR. This working group will consult with Working Group 3 throughout the Workshop to ensure that new analysis challenges and new analysis tools and methods are shared between the two working groups as their work proceeds.

4.1.5 Synthesis Group

Chair: Dr Stuart Starr, FS
Co-Chair: Dr Jerry Kotchka

This group will take a broad view, identifying the high level issues across the domains of policy, organization, process, technology, and training that enable or impede the successful evolution of both analytic practice and knowledge management in the MORS community. The Synthesis Group will provide the integrating perspective.

4.2 Working Group Tasking

Working groups will be directed to address the following questions and concerns in the following priority order:

To what degree and in what terms may the working group's focus area be defined?

How may the working group's area of focus be addressed to meet current and future needs?

Working groups will define up to three priority issues that they feel must be addressed to enable their focus area to be improved. Each priority issue will be defined along with a summary action plan recommending how the issue may be addressed. The summary action plan will recommend an action organization, supporting organizations, and principal steps to action resolution.

5. Sequence of Events

A working group chair and co-chair warm-up session will be held the evening before the first day of the workshop. This session will be held at the workshop hotel. The purpose of this warm-up session is to review and discuss the tasking for the working groups.

The morning of the first day will be devoted to a plenary session. The Workshop Chair will present the goals, objectives, and organization for the workshop. Mr Roske will present the charge to the workshop participants. The plenary session speakers will provide alternative perspectives on analytical practice in DoD and knowledge management in DoD. The first keynote speaker will address the emerging concept of

enterprise knowledge management and how it enables improved decisionmaking. The second and third keynote speakers will provide the decisionmakers' requirement for improved analysis.

There will be a social event (mixer) at the end of the first day.

There will be a luncheon speaker on the first and second day.

The afternoon of the first day and all of the second day will be devoted to working group sessions and discussions. The morning of the third day will be devoted to the preparation of working group presentations. The afternoon of the third day will be devoted to working group presentations in plenary session.

The morning of the fourth day will be made available to working group chairs and co-chairs for final editing of the working group annotated briefings.

6. Agenda

Day/Time	Activity	POC	Location
Monday	February 28, 2000		
1900	Working Group Co-Chair Warm-Up Session	Mr Denis Clements	Hotel
Tuesday	February 29, 2000		
0700	Registration and Continental Breakfast	MORS Office	NPS
0800	Call to Order and Opening Remarks	Mr Denis Clements	NPS
0805	Welcome by Host	Prof. Dave Schrady	NPS
0810	Sponsor's Welcome and Workshop Kick-Off	Mr Vince Roske	NPS
0830	Keynote: "Enterprise Knowledge Management"	Dr Ruth David	NPS
0930	Break		NPS
0945	Speaker: "Perspectives on Requirements Analysis"	Mr Jim Johnson	NPS
1045	Speaker: "Perspectives on Capabilities Analysis"	VADM Conrad Lautenbacher	NPS
1145	Charge to the Working Groups	Mr Denis Clements	NPS
1200	Lunch with Guest Speaker:	MORS Office, Speaker	NPS
1330	Working Group Session #1	Working Group Co-Chairs	NPS
1510	Break	MORS Office	NPS
1520	Working Group Session #2	Working Group Co-Chairs	NPS
1700	Adjourn Regular Session	Mr Denis Clements	NPS
1700	WG Chair and Co-Chair Hot Wash	Mr Denis Clements	NPS
1715-1900	Mixer	MORS Office	NPS
Wednesday	March 1, 2000		
0715	Continental Breakfast	MORS Office	NPS
0800	Plenary Session: "QDR Workshop Report"	Mr Mike Leonard	NPS
0900	Working Group Session #3	Working Group Co-Chairs	NPS
1015	Break	MORS Office	NPS
1030	Working Group Session #4	Working Group Co-Chairs	NPS
1200	Lunch With Guest Speaker:	MORS Office, Speaker	NPS
1330	Working Group Session #5	Working Group Co-Chairs	NPS
1515	Break	MORS Office	NPS
1530	Working Group Session #6	Working Group Co-Chairs	NPS
1700	Adjourn Regular Session	Mr Denis Clements	NPS
1700	WG Chair and Co-Chair Hot Wash	Mr Denis Clements	NPS
Thursday	March 2, 2000		
0715	Continental Breakfast	MORS Office	NPS
0800	Working Groups: Prepare Briefings	Working Group Co-Chairs	NPS
0945	Break	MORS Office	NPS
1000	Working Groups: Prepare Briefings	Working Group Co-Chairs	NPS

1230	Lunch	MORS Office	NPS
1330	Working Groups: Present Briefings, WG 1, 2, 3	Working Group Co-Chairs	NPS
1500	Break	MORS Office	NPS
1515	Working Groups: Present Briefings, WG 4 and Synthesis Group	Working Group Co-Chairs	NPS
1615	Workshop Wrap-Up	Mr Denis Clements	NPS
1630	Adjourn	Mr Denis Clements	NPS
Friday	March 3, 2000		
0700	Working Group Co-Chairs complete Working Group Annotated Briefings	Working Group Co-Chairs	NPS
1100	Adjourn Workshop	Mr Denis Clements	NPS

7. Attendees

Attendance will be controlled via invitation. Attendees will include invited experts from OSD, all Services, the Joint Staff, Federally Funded Research and Development Centers, operational commanders, and DoD contractors. Workshop chairs will control membership of their sessions in conjunction with the Organizing Committee. Attendance will be limited to 120 people.

8. Products

There will be four specific products generated as a result of this workshop:

- An Executive Summary in the form of a text document and a scripted briefing for the MORS Sponsors addressing the workshop objectives, findings, conclusions, and recommendations.
- A proceedings containing summaries of all sessions and copies of appropriate briefing slides and presentations.
- A general session presentation for the 68th MORSS.
- A *PHALANX* article

9. Milestone Plan

Action	Who (1)	Due
Pre-Workshop Planning Milestones		
Initiate draft TOR procedure	Initiator	06/04/99
Select tentative dates	Initiator, VPMO EVP, VPA	08/03/99
Provide "For Comment" draft of TOR to Sponsors, EC	MORS Office	09/02/99
Revise TOR	Initiator & MORS Office	10/02/99
Circulate initial draft TOR to MORS office and committee for comments	Chair	10/12/99
Solicit candidates for working group chairs	Chair	10/12/99
Circulate final draft TOR to MORS office and proponent(s) for concurrence	MORS Office	11/01/99
Select, Invite Plenary Speakers	Chair	11/22/99
Select working group chairs	Chair	12/01/99
Provide read-ahead materials and releases to MORS Office	Committee	12/01/00
Approve TOR, Program Chair, budget and fees	EC	12/06/99
Select organizations to be invited and prepare letter inviting nominations.	Chair/Co-Chair	12/10/99
Post read-ahead materials on MORS web page	MORS Office	12/13/99

Mail invitations to nominate attendees	MORS Office	12/15/99
Submit nominations or requests for applications	Nominating organizations	12/30/99
Pre-registration, security clearances due at MORS Office	Invitees	01/14/00
Select invitees	Committee	01/21/00
Mail invitations, WG assignments	MORS Office	02/07/00
MORS Staff departs for NPS	MORS Office	2/26/00
Working Group Warm-Up Session	Chair/Co-Chair	2/28/00
Post-Workshop Planning Milestones		
Complete Annotated Briefings	WG Chairs	03/03/00
Submit *PHALANX* Article	Chair/Co-Chair	03/15/00
Brief sponsors	Chair	03/30/00
Submit After-Action Report	Chair	04/28/00
Complete written products	Committee	05/30/00
68th MORSS Presentation	Chair	06/20-22/00
Approve written products	Pubs Committee	06/28/00
Review approved products	Proponent(s)	07/28/00
Distribute approved products	MORS Office	08/28/00
Organizing Committee Meetings		
Organizing Committee Meeting-1	Organizing Committee	10/27/99
Organizing Committee Meeting-2	Organizing Committee	11/09/99
Organizing Committee Meeting-3	Organizing Committee	11/22/99
Organizing Committee Meeting-4	Organizing Committee	12/08/99
Organizing Committee Meeting-5	Organizing Committee	01/04/00
Organizing Committee Meeting-6	Organizing Committee	01/18/00
Organizing Committee Meeting-7	Organizing Committee	02/03/00
Organizing Committee Meeting-8	Organizing Committee	02/15/00

10. Proponents for the Workshop Are:

- Army
- Navy
- Air Force
- Marine Corps
- OSD
- Joint Staff

11. Planning and Organizing Chairs and Committees

Lead Proponent:	Mr Vince Roske
Chair:	Mr Denis Clements
Co- Chair:	Ms Sue Iwanski
Synthesis Chair:	Dr Stuart Starr
NPS Site Coordinator:	CDR Matt Boensel
Administrative Coordinators:	Richard Wiles and Natalie Kelly MORS, Suite 202 101 S. Whiting Street Alexandria, VA 22304 (703) 751-7290
Organizing Committee:	Army, Dr Bob Hinkle, MAJ Bruce Simpson Navy, Mr Chuck Werchado Air Force, Mr Clay Thomas, Lt Col Kirk Yost Marine Corps, Capt Russ Bergeman OSD, LTC Dan Maxwell

	Joint Staff, COL Bob Clemence
	AFSPACECOM, Maj Suzanne Beers
	NPS, Dr Dave Schrady, Dr Steve Pilnick
Institutional Members:	IDA, Dr Tom Allen
	MITRE, Dr Stuart Starr
	LMCO, Dr Jerry Kotchka
	SAIC, Ms Annie Patenaude

12. Administration

Name: Ms Natalie Kelly
Dates: February 28, 2000 through March 3, 2000
Location: Naval Postgraduate School, Monterey, CA
Fee: Federal Government Employees $190; All others $380
Attendance: Limited to 120
Classification: UNCLASSIFIED

Hotel: Hyatt Regency, Monterey, #1 Old Golf Course Road, Monterey, CA 93940, 831-372-1234, Ask for the MORS Block of RooMs

APPENDIX A: DESCRIPTION OF KNOWLEDGE MANAGEMENT

The three essential aspects of knowledge management are knowledge discovery, expansion, and capture, knowledge organization, and knowledge sharing, see Figure 1. We discover knowledge where it is: in the heads of people, in manuals and reports, and mined from every node of the Internet and the SIPRNET. We must expand knowledge through research and development, by examining the problems for which we do not have the techniques and tools in place. We must capture the knowledge that we discover and create. We must organize the knowledge according to a preferred scheme or taxonomy and we must share that knowledge among the analysts and subject matter experts so we may derive benefit from it.

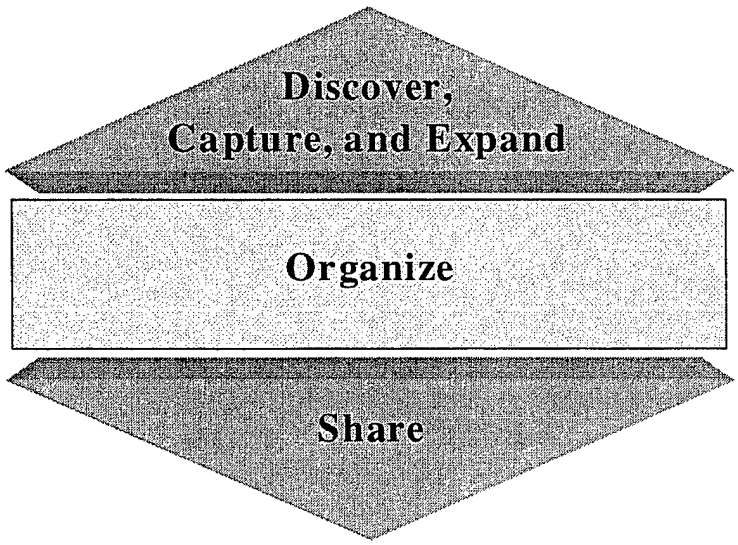

Figure 1. The Essential Components of Enterprise Knowledge Management

The discovery, expansion, capture, organization, and sharing of knowledge can be accomplished by leveraging current initiatives and disciplines. Starting with the wealth of information and data currently available in manuals, reports, the GCCS and GTN data stores, and automated open sources, we can leverage our tacit and explicit knowledge by building a knowledge management structure on top of six key pillars: advanced data analysis, knowledge discovery and mapping, Knowledge expansion, expertise location, collaboration, and knowledge transfer, see Figure 2.

Advanced data analysis is much more than the traditional data analysis. It describes the processes, tools, and techniques that, when combined, are used to enable improved decisionmaking. Data analysis must expand to include data mining, on-line analysis processing (OLAP), correlation landscapes, influence diagrams, and other advanced technologies that can be used for gleaning valuable insights from stored data.

Knowledge discovery includes text mining techniques that enable knowledge discovery from text sources. ***Knowledge mapping*** is the technique for representing knowledge sources (people and information nodes) in a context defined by their relationships.

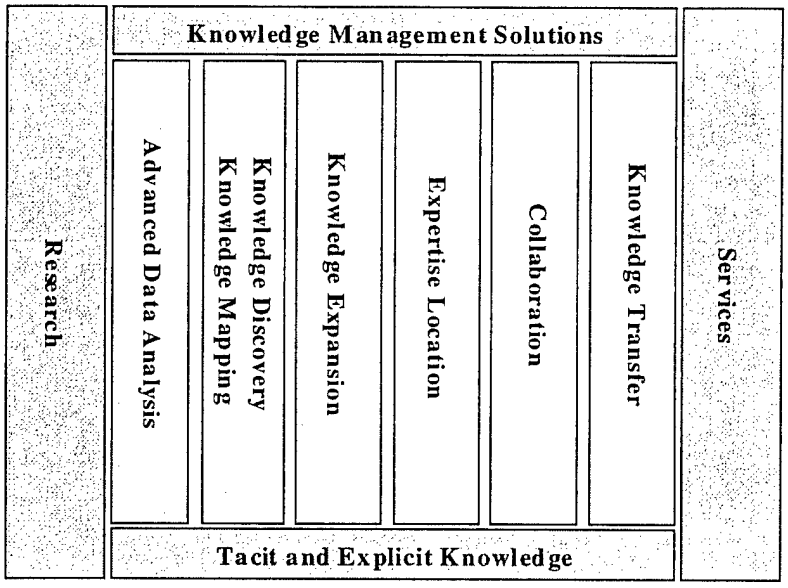

Figure 2. The Pillars of Knowledge Management

Knowledge expansion depends on the examination of current and future analytical need. As these new analytical problems are identified, appropriate investments must be made to ensure that research and development is planned and performed to define and develop new tools and techniques to address the ever-changing landscape of military operations analysis.

Expertise location includes finding, cataloging, and making available the best expertise available in the DoD components when needed for analysis in support of military decisionmaking.

Collaboration enables people to share information, expertise, and insights, which results in an amplification of tacit knowledge, which in turn, results in enhanced innovation and motivation.

Knowledge transfer extends the reach of the available knowledge and skill transfer resources to remote locations, enabling virtual teams to perform at high-level organizational standards, independently of the geographical location of team members.

Knowledge management is a new discipline and is receiving fruitful, innovative tools and techniques from the research community. The introduction of the processes, tools, and techniques of knowledge management in the Military Operations Research community will allow us to be more effective in providing analysis and insight on important issues to the DoD leadership.

APPENDIX B: KNOWLEDGE MANAGEMENT BIBLIOGRAPHY

Books:

Thomas H. Davenport and Laurance Prusak, Working Knowledge: How Organizations Manage What They Know, Harvard Business School Press, 1998

Leif Edvinsson and Michael S. Malone, Intellectual Capital: Realizing Your Company's True Value by Finding Its Hidden Brainpower, HarperBusiness, 1997

Arie de Geus, The Living Company, Harvard Business School Press, 1997

Dorothy Leonard, Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation, Harvard Business School Press, 1995

Ikujiro Nonaka and Hirotaka Takeuchi, The Knowledge Creating Company: How Japanese Companies Create the Dynamic of Innovation, Oxford University Press, 1995

Thomas A. Stewart, Intellectual Capital: The New Wealth of Organizations, Doubleday, 1997

Karl-Erik Svieby, The New Organizational Wealth: Managing and Measuring Knowledge-Based Assets, Berret-Koehler, 1997

Lester Thurow, Building Wealth: The New Rules for Individuals, Companies, and Nations in a Knowledge-Based Economy, HarperCollins, 1999

Gurus:

John Seely Brown
Chief Scientist, XEROX and Director of XEROX PARC
http://www.parc.xerox.com

Ruth David
President and CEO, ANSER
Formerly: Deputy Director for Science and Technology, CIA
Implemented: Agile Intelligent Enterprise (AIE)

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http://www.bootstrap.org

Dorothy Leonard
Harvard Business School, Cambridge, MA
http://www.harvard.edu

Charles Kirk
American Productivity and Quality Center
http://www.apqc.org/best/km/

Paul Strassman
http://www.strassmann.com/index.shtml

Karl-Erik Sveiby
Sveiby Knowledge Management
http://203.32.10.69/default.htm

Daniel Tkach,
Technology Director, Institute for Knowledge Management, IBM

High Quality Commercial Vendors:
Autonomy, Inc.
http://www.autonomy.com

Instinctive Technology, Inc.
http://www.instinctive.com

International Business Machines, Inc.
Knowledge Management Consulting and Services Practice
Scott J. Smith, smithjs@us.ibm.com
http://www-4.ibm.com/software/data/knowledge/
http://www-3.ibm.com/solutions/businessintelligence/
http://www.software.ibm.com/data/km/knowledgex

Inxight Software - Spin-off from Xerox PARC
http://www.inxight.com

Lotus Development Corporation, Inc. (owned by IBM)
http://www.lotus.com/quickplace
http://www.lotus.com/news/news.nsf/public/14F6B23E55BBC352852567B400628852

Semio Corporation, Inc.
http://www2.ideograf.com/semio/index.html

Xerox Corporation, Inc.
http://www.xerox.com/products/docushare

Periodicals:
Knowledge Management Magazine
http://www.kmmag.com
STRATEGY: http://kmmag.com/kmmagn2/km199908/featurec2.htm
CULTURE: http://kmmag.com/kmmagn2/km199908/featurec3.htm
PROCESSES: http://kmmag.com/kmmagn2/km199908/featurec4.htm
TECHNOLOGY: http://kmmag.com/kmmagn2/km199908/featurec5.htm

KM Implementations:
Sugi Sorenson
Jet Propulsion Laboratories, Pasadena, CA

Universities:
Carnegie-Mellon University
Center for Automated Learning and Discovery
Program in Knowledge Discovery and Data Mining
http://www.cs.cmu.edu/~kdd/intro.html

Harvard University
http://www.harvard.edu

Search on: knowledge management

Massachusetts Institute of Technology
http://www.mit.edu
Search on: knowledge management

Other Sources:
US Army Web Briefing on Knowledge Management
http://www.army.mil/ako/WebBriefing/sld001.htm

WWW Virtual Library on Knowledge Management
http://www.brint.com/km/

Special Libraries Association
www.sla.org/membership/irc/knowledg.html

Artificial Intelligence Applications Institute
www.aiai.ed.ac.uk/~alm/kamlnks.htm

University of Colorado, Denver
www.cudenver.edu/~mryder/itc_data/org_learning.html

Another very good Bibliography
http://www.irit.fr/ACTIVITES/EQ_SMI/GRACQ/biblio-ke.html

Appendix D: Participants
Evolving the Practice of Military Operations Analysis in DoD
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